18.5 MICROWAVE HUMIDITY SOUNDER (MHS)

18.5.1 FUNCTIONAL DESCRIPTION

The Microwave Humidity Sounder (MHS) is a five channel self-calibrating microwave radiometer. MHS, together with the complementary AMSU-A instruments, provides the operational microwave sounding capability for the TIROS (NOAA-N onwards) meteorological satellites.

MHS has channels in the 89-190 GHz range. Channels at 157 GHz and around 183 GHz provide a humidity profile sounding capability, while the 89 GHz channel provides information on surface temperature and emissivity (in conjunction with AMSU-A channels) and detects cloud and precipitation contaminated pixels.

MHS is a cross-track, line scanned instrument designed to measure scene radiance in five discrete frequency channels. At each channel frequency, the antenna beam width is 1.1° (at the half power point). Ninety contiguous scene resolution cells are sampled in a continuous scan every 2.67 seconds, each scan covering 50° on each side of the subsatellite path. These scan patterns and geometric resolution translate to a 17 km diameter cell at nadir from the 870 km nominal orbital altitude.

18.5.2 SYSTEM DESCPRIPTION

18.5.2.1 General

The MHS instrument is based upon an offset paraboloid reflector which is mechanically scanned to provide earth scene, on-board target and cold space views (the latter two for calibration). The scan motion is fully compensated by a counter rotating motor driven flywheel. The reflector illuminates feeds at 89, 157, 183 and 190 GHz via a quasi optical arrangement of lenses, dichroic plates and a polariser. The instrument channel and passband characteristics are as shown in Figure 18.5-1.

The scientific data generated by MHS is output to the spacecraft via the MHS Interface Unit (MIU) on the Science Data (SD) bus using CCSDS packet formats. Instrument command, control and telemetry functions are achieved using a separate Command/Telemetry (CT) bus, also using CCSDS packet formats.

The instrument functional block diagram is presented in Figure 18.5-2; the main fu[illegible] instrument are described below.

6

MHS P&C Handbk

18.5.2.2 Scan Control

A scan mechanism consisting of two motors with their associated drive electronics supports a single reflector assembly and performs the scanning of the instrument field of view across the Earth, an on-board hot calibration target and cold space for instrument calibration, every 2.67 seconds. The scanning principle is shown in Figure 18.5-3.

CHAN NO	CENTRE FREQ (GHz)	No OF PASS-BANDS	MAXIMUM BANDWIDTH (MHz)	CENTRE FREQ STABILITY (MHz)	TEMP SENSITIVITY NEΔT (K) GOAL	REQ'D	ABSOLUTE CALIB-RATION ACCURACY (K)	INTER-CHANNEL CALIB-RATION ACCURACY	PRIME POLARI-SATION
H1	89.0	1	2800	±40	0.6	1.0	±1.0	0.5	V
H2	157.0	1	2800	±100	0.6	1.0	±1.0	0.5	V
H3	183.311 ± 1.0	2	1000	±50	0.6	1.0	±1.0	0.5	-
H4	183.311 ± 3.0	2	2000	±70	0.6	1.0	±1.0	0 5	-
H5	190.311	1	2200	±70	0.6	1.0	±1.0	0.5	V

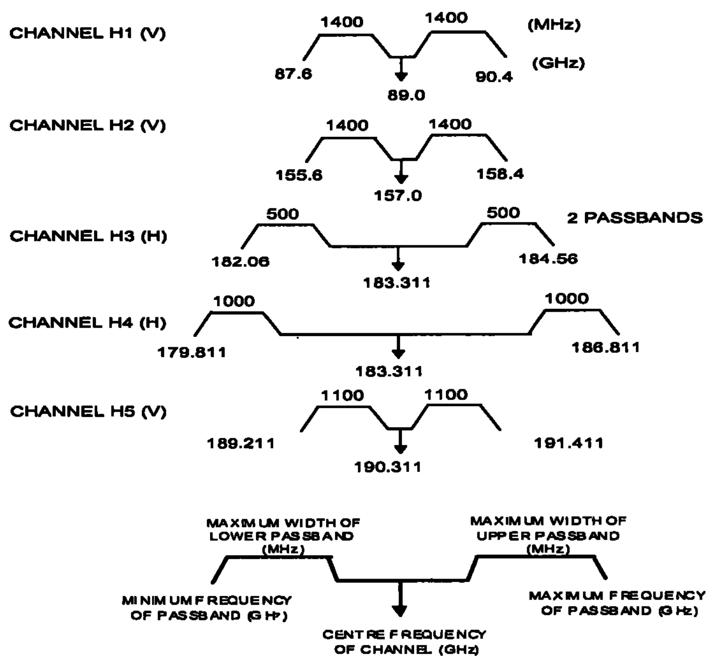

Figure 18.5-1. MHS Channel and Passband Characteristics

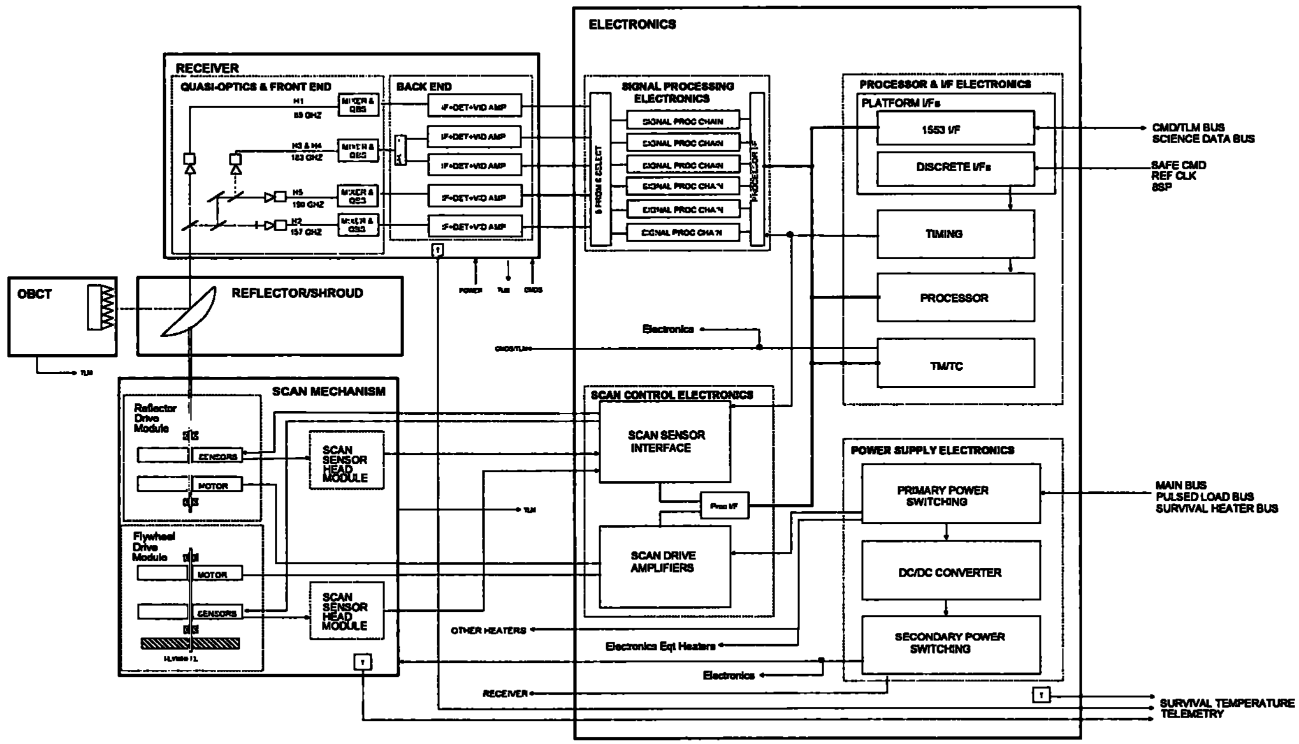

Figure 18.5-2. Instrument Functional Diagram

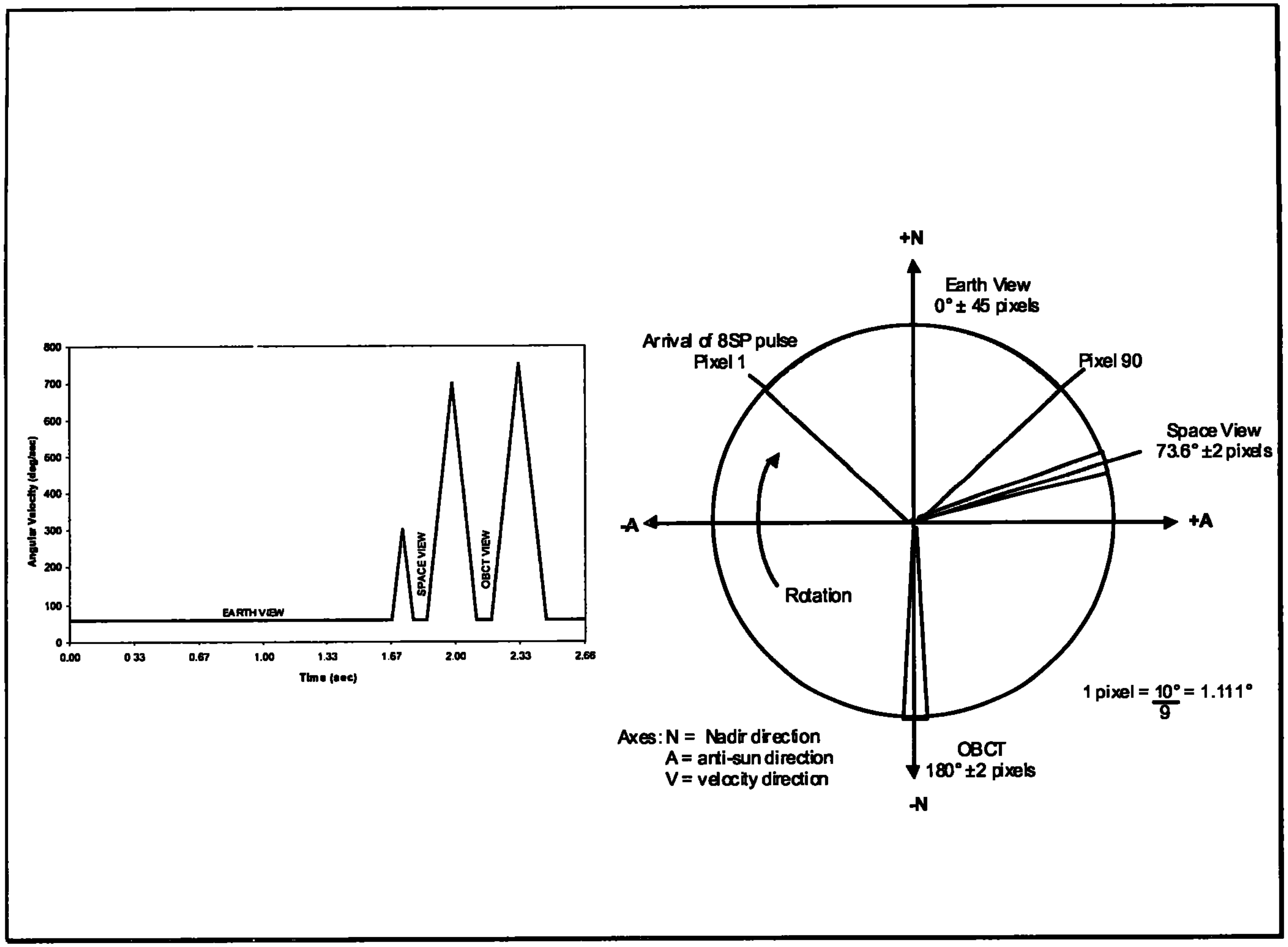

Figure18.5-3. MHS Scanning Principle

One of the motors drives a compensating flywheel providing momentum compensation to limit the perturbations introduced on the attitude of the satellite by the scan motion. The scan profile is optimised for maximum radiometric sensitivity.

18.5.2.3 Microwave Signal Reception

The MHS instrument is a microwave total power radiometer with five measurements channels called H1 to H5 at respectively 89 GHz, 157 GHz, 183.3 GHz, 183.3 GHz, 190.3 GHz centre frequencies.

The reflector driven by the scan mechanism directs the RF signal to a quasi optical assembly. This assembly splits the signal according to the frequency and required polarisation. H1, H2 and H5 channels have separate feeds whereas H3 and H4 are combined on the same feed.

18.5.2.4 Signal Detection

The microwave signal at the output of each feed is down converted to Intermediate Frequency (IF) using a superheterodyne receiver consisting of one mixer (fundamental for H1, sub-harmonic for other channels) with its associated local oscillators (nominal + redundant), amplifiers, a diplexer for H3/H4, a filter section and video detection. This generates five baseband signals.

18.5.2.5 Signal Processing

The detected baseband signals are filtered and the DC component (corresponding to the receiver noise level) removed. The signal is then digitised and a digital accumulation over each pixel integration period performed. The final pixel result is formatted into a packet along with the calibration data to constitute the scientific data to be used on the ground.

18.5.2.6 Instrument Control and Telemetry

A processor controls and monitors the instrument operation and the scan position and velocity. Associated electronics provide the electrical interface with the spacecraft and generate the secondary supplies necessary for the instrument equipments.

18.5.2.7 On-board Calibration Target

As identified above, a "hot target" is scanned every 2.67 seconds and provides a hot reference temperature for instrument calibration. This target consists of an array of pyramids coated with RF absorbing material. It is passively controlled at ambient to obtain a uniform temperature over the surface. This temperature is accurately measured and used for on-ground processing of the radiometric data.

18.5.2.8 Structure and Thermal Control

All four MHS equipments, namely scan mechanism assembly, receiver, electronics and on board calibration target are mounted onto a single structural baseplate which ensures the mechanical interface with the spacecraft.

Passive thermal control is employed for MHS, using a combination of thermal insulation and radiative surfaces. "Cold" surfaces are specifically used for dissipating the power of the receiver and the electronics equipment. Heaters are provided to speed up the warm-up time of the instrument from switch-on. Survival heaters are provided to maintain safe temperatures when the instrument is off.

18.5.3 MECHANICAL ASSEMBLY

Figure 18.5-4 shows the general mechanical assembly of the MHS. The MHS instrument consists of three major equipments as described below.

18.5.3.1 Receiver

This equipment can be further divided into two sections:-

Quasi-Optics and Front-End Assembly (QOFEA): consists of the mirrors, lenses, polarisors and horns of the quasi-optics; and the Q-band sources (QBSs), mixers, LNAs and Down-Converters (DCs)

IF Back-End (IFBE) functions: consists of IF filters, detector diodes and programmable gain baseband amplifiers. It also includes a relay switch network to allow independent on/off control of the Rx channels.

18.5.3.2 Scan Mechanism (SM)

This provides a motor to drive the Reflector (Reflector Drive Module, RDM) and a second motor to drive the momentum compensation flywheel (Flywheel Drive Module, FDM). Each motor has an Inductosyn angular position sensor with an associated preamplifier module (Scan Sensor Head Module, SSHM) mounted close to the motors.

18.5.3.3 Electronics Equipment (EE)

This consists of 11 circuit modules providing the following functions:-

- Processor and Interface Electronics (PIE) (5 modules)

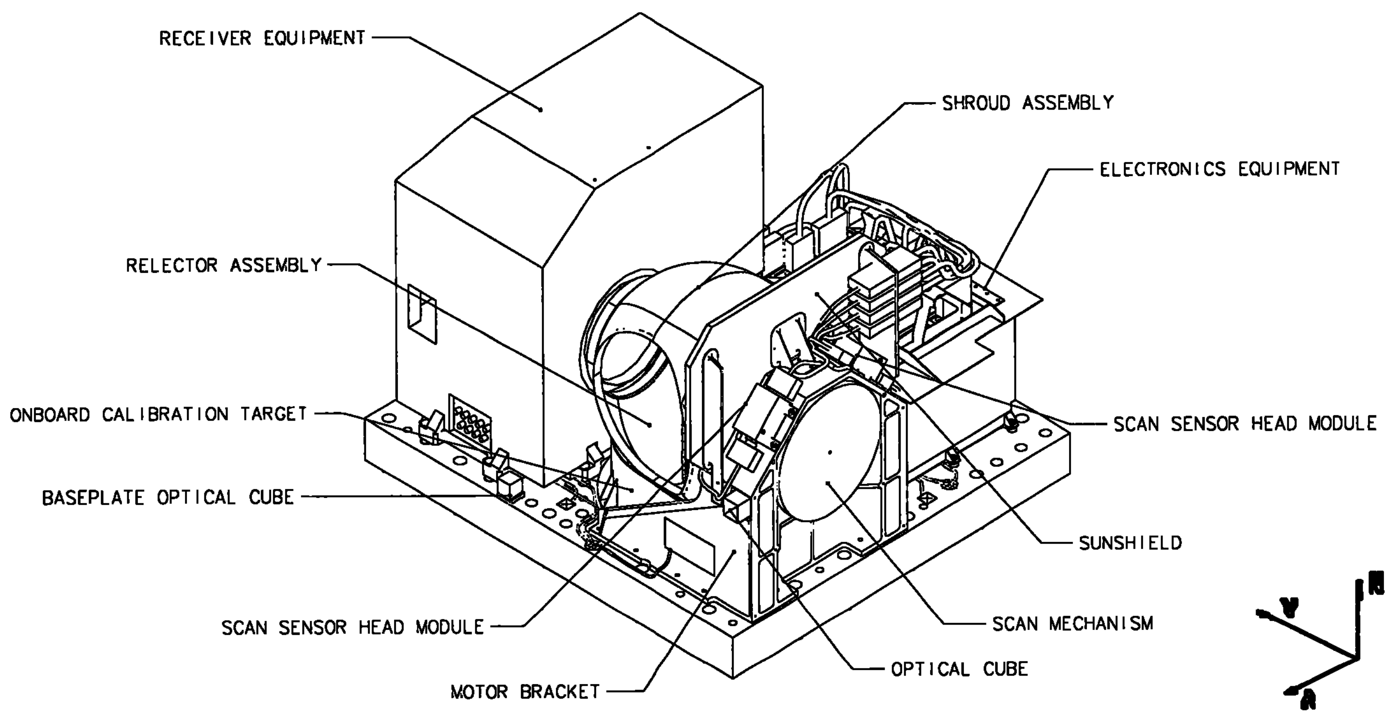

Figure 18.5-4. MHS General Assembly

This provides the processor, PROM and RAM which executes the MHS Instrument On-board Software (MINOS). It also provides interfaces to the MIU and to the other MHS equipments. The software decodes commands from the MIU, initiates internal commands to the equipments, gathers telemetry, gathers scientific data, formats data into packets and outputs them to the MIU. It also implements the scan control algorithms used to control the Reflector and Flywheel positions. The PIE has full cold redundancy.

- Signal Processing Electronics (SPE) (1 module)

  This accepts the baseband signals from the Receiver and generates a digitised result for each image pixel and each channel. It performs filtering, dc bias removal, digitisation and digital integration. There is one signal processing chain for each Receiver channel, plus one redundant chain which can replace any of the other five chains.

- Scan Control Electronics (SCE) (2 modules)

  This provides the interfaces to the motors and sensors of the Scan Mechanism. The Scan Drive Amplifiers (SDAs) accept a torque demand from the processor and generate the required current in the 3-phase motor windings. The Scan Sensor Interface provides the necessary signals for the Inductosyn position sensors and the hall-effect zero position sensors and generates a digital output representing the angular position of the motor.

- Power Supply Electronics (PSE) (2 modules)

  This provides two DC/DC converters to generate secondary supplies for the PIE+SPE+SCE functions and the Rx functions respectively. It also provides primary power switching for bus redundancy selection and heater power, and secondary power on/off switching.

  - Spare Module (1 Module)

  This module is empty.

The instrument also has the following minor equipments/assemblies:-

- On-Board Calibration Target (OBCT)
- Reflector and Shroud assembly
- Motor Bracket and sunshield
- Thermal hardware (thermistors, thermostats and heaters)
- Instrument Baseplate

18.5.4 MHS OPERATION

18.5.4.1 Modes of Operation

The overall control of the MHS Instrument is performed through operation in the modes described in the following sections. The status of the MHS Instrument in the various modes and the transitions between modes are controlled by the MHS Instrument Onboard Software (MINOS).

Figure 18.5-5 shows the flow between modes and the stimuli that cause the mode changes.

Figure 18.5-6 shows the status of the MHS equipments in different modes.

Figure 18.5-7 shows the telemetry and science data output for different modes.

Figure 18.5-8 shows the status of survival and operational heaters during various modes.

18.5.4.1.1 Launch Mode

In this mode the MHS Instrument is unpowered. Transition to Off Mode occurs when Survival Power is applied and Main Bus power and Pulse Load power are not present.

18.5.4.1.2 Off Mode

In this mode the MHS Instrument is unpowered.

Thermostatically controlled Survival Heaters are used to maintain equipment temperatures within their non-operating (survival) limits. The Electronics Equipment (EE) is maintained at the minimum switch-on limit so that when Main Power is applied (i.e. transition to Power-On Mode) the EE can be immediately switched on safely. The Survival Heaters are powered from the Survival Bus.

In all other powered modes (assuming both Main Bus and Pulsed Load Bus are on) the Survival Heaters are not powered due to the isolation switch in the Power Supply Electronics (PSE).

18.5.4.1.3 Power-on Mode

The purpose of this mode is:

- to establish command and telemetry links with the MHS Instrument with a minimum amount of circuits powered to establish the health and status of the MHS Instrument control and telemetry functions

- to warm up the unpowered equipments to minimum switch-on temperatures

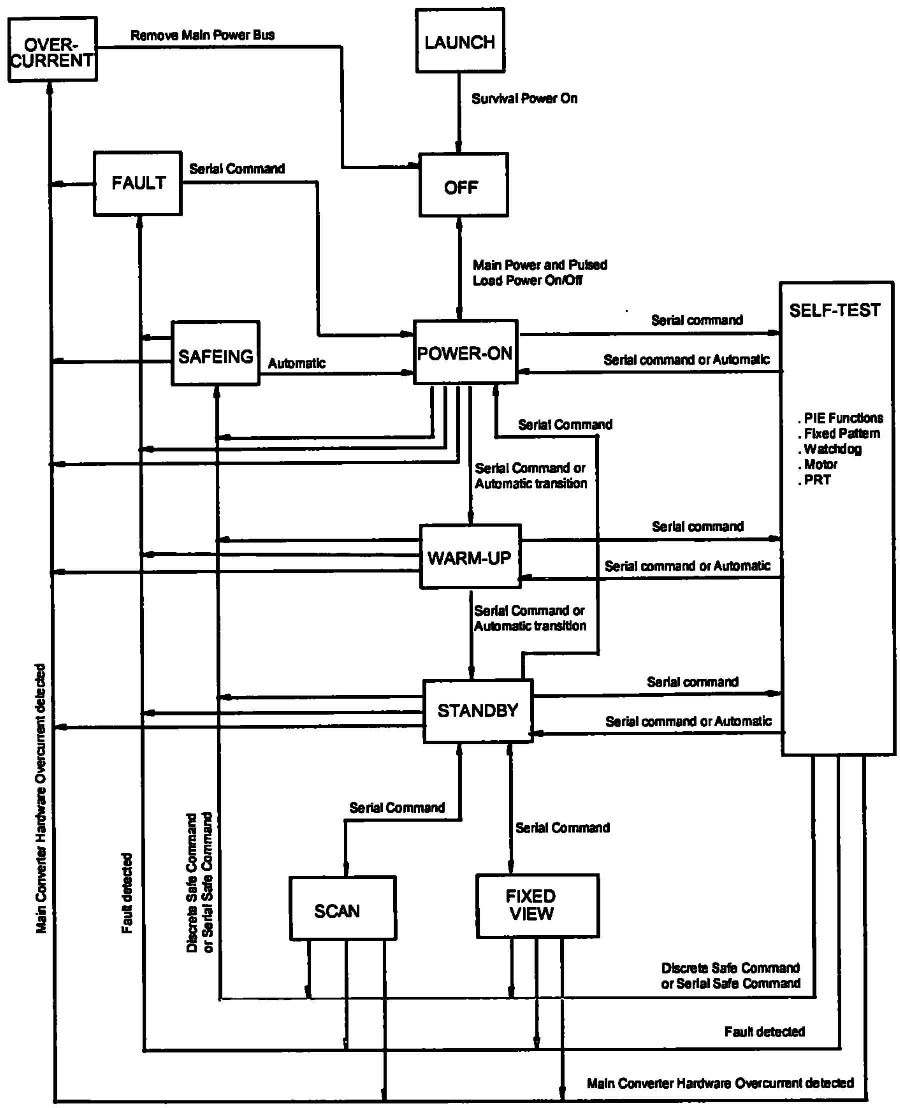

Figure 18.5-5. MHS Modes and Mode Transitions

MHS INSTRUMENT STATUS (Note 1)								
MODE	PIE	SCE SPE SSHM	Receiver	Motor Drive	Rx Op Heaters	SM Op Heaters	Aux Op Heaters	Survival Heaters
LAUNCH	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON
OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON
POWER-ON	ON	OFF (note11)	OFF (note 8)	OFF	ON	ON	note 12	OFF
WARM-UP	ON	ON	ON	OFF	OFF	ON	note 12	OFF
STANDBY	ON	ON	ON	ON	OFF	OFF/ON (note 4)	note 12	OFF
SCAN	ON	ON	ON	ON	OFF	OFF	note 12	OFF
FIXED VIEW	ON	ON	ON	ON	OFF	OFF/ON (note 4)	note 12	OFF
SELF-TEST	ON	ON	ON/OFF (note 5)	ON/OFF (note 5)	OFF/ON (note 3)	OFF/ON (note 4)	note 12	OFF
SAFEING	ON	ON	OFF	OFF (note 7)	ON	ON	note 12	OFF
FAULT (note 10,11)	ON	ON (note 2)	OFF	OFF (note 7)	ON	ON	note 12	OFF (note 2)
OVERCURRENT	OFF	OFF	OFF	OFF	OFF	OFF	note 12	OFF (note 6)

Note 1 The table shows the status after completion of the mode transition.

Note 2 In case of the following causes, the SPE/SCE/SSHM functions are turned OFF:-

- 5V current monitor (supplies EE & SM sensors)
- SM temperature (including SSHM temperature, as monitored by 'Structure' thermistors)
- EE temperature

In this case, the platform will monitor the MHS Instrument temperatures (via serial TM and Survival Thermistor TM). The EE has no operational heaters and switch-on/survival temperature cannot be guaranteed if part of the EE is switched off. If operating temperatures are not maintained, the platform must switch off the MHS Instrument and ensure Survival Power is on so that the MHS Survival Heaters can maintain temperatures.

Note 3 When the Rx is OFF, the Rx Operational Heaters are either ON or OFF, under control of the software on the basis of Receiver thermistor telemetry.

Note 4 When the Motor Drive is under fixed position control, the processor controls the SM Operational Heaters as necessary because the motor power dissipation is very low.

Note 5 Depends on previous (i.e. calling) mode and type of test performed.

Notes continued on next page

Figure 18.5-6. Equipment Status for MHS Modes

Note 6 In this non-nominal mode, the platform must manage the power buses to achieve thermal control using Survival Thermistor Telemetry and Survival Heaters.

Note 7 The Reflector is parked at the OBCT before turning OFF the Motor Drive for Safeing Mode and the following causes of Fault Mode: RFCV H/W trip, RFCV current monitor, Rx & Structure (not SSHM) temperature monitors.

Note 8 The Rx and RFCV are OFF on entry to this mode, but the RFCV (within the EE) will nominally be switched ON by telecommand soon after entry to this mode.

Note 9 The causes of a transition into FAULT MODE are:-

- RFCV H/W trip
- RFCV current (8V,±15V) TLM out of 'Fault Limits'
- EE/SM current (+5V) TLM out of 'Fault Limits'
- RDM/FDM current (28V) TLM out of 'Fault Limits'
- RX/SM/EE/Structure temperature TLM out of 'Fault Limits'
- Switch status telemetry error
- Loss of Platform REF CK (and therefore Scan Control Clock).
- Failure to initialize Zero Position Sensors

(Note: If temperature is out of 'Warning Limits' then a TM flag is raised but there is no change of mode; if outside 'Fault Limits' then FAULT MODE is entered.)

Note 10 When in FAULT MODE the software shall:-

- perform no Scan Control functions (except see note 7)
- perform no SPE functions
- perform TM/TC functions
- wait for serial commands for diagnostics or to switch to POWER-ON mode.

Note 11 On initial entry to Power-On Mode the SCE/SPE/SSHM will be off. They will nominally be switched on by serial command soon after entry to this mode.

Note 12 The Aux Op Heaters act as a cold redundant set of Rx Op Heaters. Selection is made under software control, in accordance with the Instrument Configuration Table.

MHS INSTRUMENT MODE	CMD/TLM BUS	SCIENCE BUS
LAUNCH	none	none
OFF	none	none
POWER-ON	HK TLM Packet Memory Data Packet	Science Data Packet (1) Extended Memory Data Packet
WARM-UP	HK TLM Packet Memory Data Packet	Science Data Packet (1) Extended Memory Data Packet
STANDBY	HK TLM Packet Memory Data Packet	Science Data Packet (1) Extended Memory Data Packet
SCAN	HK TLM Packet	Science Data Packet
FIXED VIEW	HK TLM Packet	Science Data Packet
SELF-TEST	Test Data Packet	Extended Test Data Packet
SAFEING	HK TLM Packet	Science Data Packet (1)
FAULT	HK TLM Packet Memory Data Packet	Science Data Packet (1) Extended Memory Data Packet
OVERCURRENT	none	none

Note: Temperature data is available using the Survival Temperature Interfaces in all modes (including unpowered modes).

Note (1): In these modes, a Science Data Packet is returned with all science data fields set to zero in response to a request for Science Data Packet (science data is not generated in these modes).

Figure 18.5-7. Output Data for MHS Modes

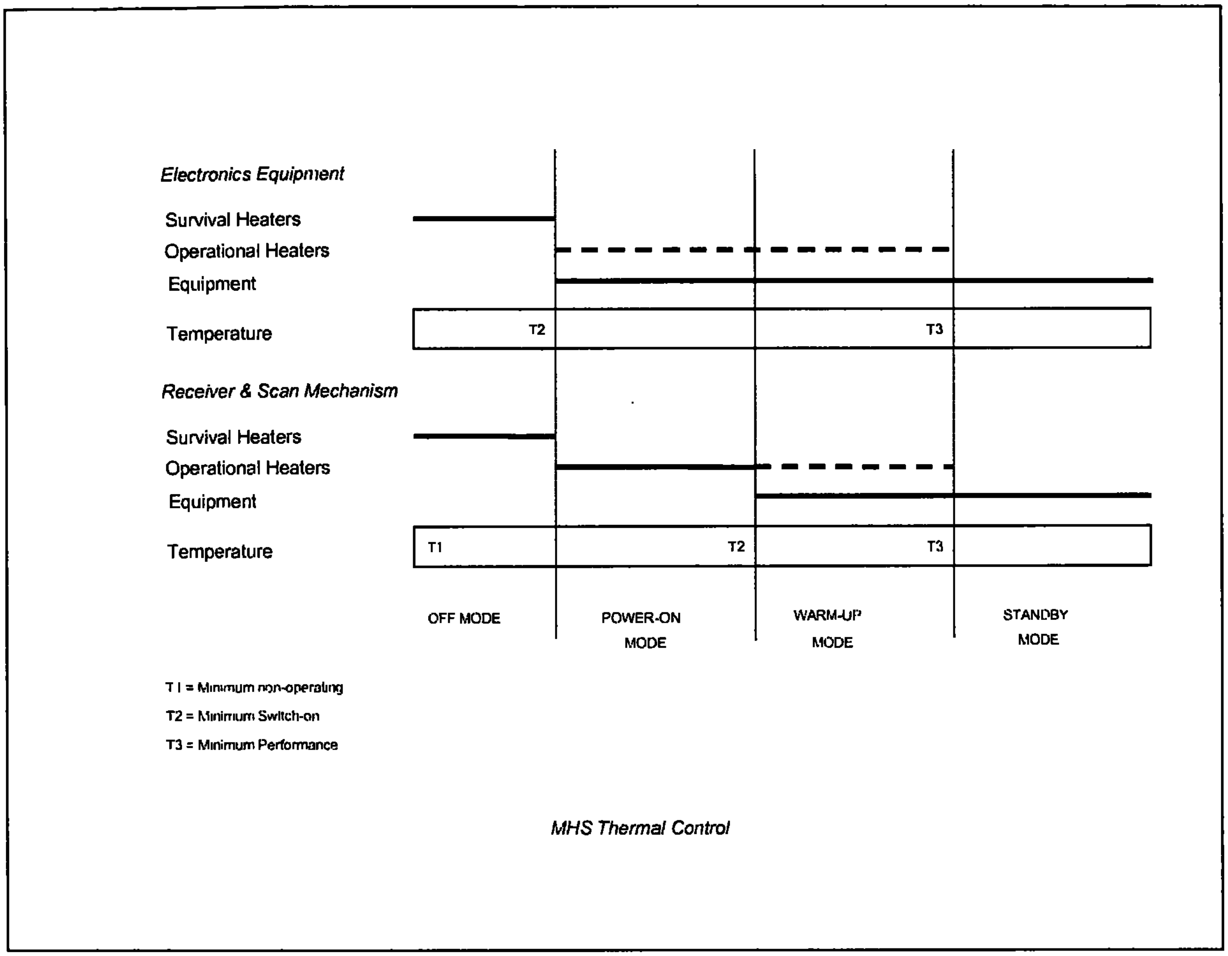

Figure 18.5-8. Survival and Operational Heater Status

This mode is normally entered from Off Mode when the MHS Instrument Main and Pulse Load Buses are applied. Initially, the PSE and one PIE function are powered. The PIE redundancy is determined by which Main Power Bus is applied. For example, if Bus A is applied then PIE A is on and PIE B is off. If both buses are on simultaneously the bus which was applied first determines the PIE selection.

Communications links are established between the MHS Instrument and the MIU, allowing the acquisition of HK telemetry to determine all equipment temperatures and serial commands can be sent to perform self-test routines to check specific EE functions.

The SCE (and therefore SM sensors and SSHM) and SPE functions are initially unpowered in this mode, but they will be switched on in response to a serial command. This will be done immediately after entering Power-on Mode so that the SPE/SCE power dissipation helps to maintain the EE at operating temperatures (the EE has no operational heaters). The SCE and SPE functions are not powered automatically by the software in case a fault condition exists (see Overcurrent Mode). Note that when the SCE are powered, the motor drive circuits are disabled (i.e. motor windings have zero current).

The Receiver (Rx) is unpowered in this mode. However, the Rx DC/DC converter (RFCV) will be switched on in response to a serial command, in order to maintain the EE at operating temperatures (see paragraph above). Both on entry to Power-on Mode, and in response to the RFCV switch-on command, the software will set all the relay switches in the Rx to the off position (if not already so) so that the Rx remains unpowered when the RFCV is switched on.

The contents of all data tables can be changed by serial telecommand in this mode, as well as in Warm-up, Standby and Fault Modes. This applies to the Instrument Configuration Table (ICT), Telemetry Limits Table (TLT), Scan Control Table (SCT) and DC Offsets Table (DOT). See section 18.5.4.6 for explanatory notes on these tables.

The Survival Heaters are unpowered in this mode, even if the Survival Heater Bus is still on (provided the Main Bus and Pulse Load Bus are both ON). The Operational Heaters are immediately powered on (by software command) so that the equipment temperatures cannot fall below non-operating limits. In fact, the Operational Heaters warm-up the Rx and Scan Mechanism from non-operating temperature limits to minimum switch-on temperatures. The EE does not have Operational Heaters; the dissipation of the equipment circuits is sufficient to reach and maintain operating temperatures from initial switch-on, provided all functions of the EE are powered.

18.5.4.1.4 Warm-up Mode

The purpose of this mode is to warm up the MHS Instrument equipments to their full performance operating temperatures. The SM operational heaters are used (if necessary) to minimize the time required to achieve these performance temperatures, or to maintain this condition.

This mode in entered from Power-on Mode either by serial command or automatically. The PIE performs the automatic mode transition in one of two ways:

- Either after the time defined in the Telemetry Limits Table (TLT) which has been determined by thermal analysis, after entering Power-on Mode.

- or when thermistor telemetry monitored by the PIE shows that minimum switch-on temperatures have been reached.

The automatic transition will only occur when the relevant flag in the Instrument Configuration Table (ICT) is set to the 'automatic' state. The default state of this flag following MHS Instrument switch-on (as held in PROM) is 'non-automatic' state.

When the mode is entered, the Receiver is powered. The Receiver redundancy and channel on/off status is determined by the ICT. This configuration may be subsequently changed during Warm-up, Standby and Fault Modes by using dedicated serial commands. Self-test routines can be selected by serial command to test specific EE and Rx functions during the warm-up. The SM operational heaters are powered (if necessary) to reduce the time required to achieve full performance operating temperatures.

18.5.4.1.5 Standby Mode

This mode is achieved when the MHS Instrument is ready to perform operational modes (i.e. modes where scientific data is collected). All equipments are at full performance temperatures and the circuits are powered. The Reflector is stationary and under closed loop control, pointing at the OBCT.

This mode can be entered from Warm-up Mode either by serial command or automatically (if ICT flag set to 'automatic', see Warm-up Mode). The PIE performs the automatic mode transition in one of two ways (as for Warm-up Mode):

- Either after the time defined in the Telemetry Limits Table (TLT) which has been determined by thermal analysis, after entering Warm-up Mode.

- or when thermistor telemetry monitored by the PIE shows that full performance operating temperatures have been reached.

On entry to Standby mode, the Scan Mechanism position measurement system is initialized. This is achieved by rotating the Reflector and Flywheel at least one revolution (open loop control) so that the Zero Position sensors are activated and the absolute positions are known.

Following this initialization, the Reflector is moved to the OBCT and held there under closed loop control. The Rx Operational Heaters are switched off. Heaters are not required to maintain full performance temperatures of the Rx during Standby and operational modes. The SM Operational Heaters are switched on as required, under the control of the software, in order to maintain performance temperatures. This is necessary because the dissipation of the motors when pointing at the OBCT is negligible.

Self-test routines can be selected by serial command in order to check specific functions of the whole MHS Instrument.

From this mode, the operational modes of Scan and Fixed View can be selected by serial command.

18.5.4.1.6 Self Test Mode

This mode is provided to allow specific functions of the MHS Instrument to be exercised and tested for the purposes of detailed MHS Instrument health monitoring and diagnostics. The results of the tests are telemetered back either in a Test Data Packet on the Cmd/Tlm Bus or in the Extended Test Data Packet on the Science Bus. These packets are placed in the output buffer in place of HK Telemetry Packets (Cmd/Tlm Bus) and Science Data Packets (Science Data Bus). Therefore, HK Data cannot be retrieved in this mode. Note the HK Telemetry Data Field of the Extended Test Data Packet on the Science Bus is undefined in this mode.

The type of test to be performed is identified in the 'Change Mode' serial command. The following tests are available:

- PIE Functions
- Fixed Pattern
- Watchdog
- Motor
- PRT Calibration

These self-tests are described in sections 18.5.4.1.6.1 to 18.5.4.1.6.5.

Self-tests can be called from Power-on, Warm-up and Standby modes as shown below:

Self-Test type	Power-on	Warm-up	Standby
PIE: Memory	Y	N	N
PIE: Processor	Y	N	N
PIE: TMTC switch	Y	N	N
Fixed pattern	Y	Y	Y
Watchdog	Y	Y	Y
Motor	N	N	Y
PRT Calibration	N	N	Y

All Self-Test Modes can be called in ONE-SHOT or CONTINUOUS mode. In ONE-SHOT mode tests are performed once. A minimum of one Scan Period is spent in the mode so that a minimum of one Test Packet is generated. Then the S/W automatically changes back to the calling mode. In CONTINUOUS mode the tests are repeated until a Mode Change serial command is received. Test packets are generated for each Scan Period spent in the Self-Test Mode.

Self-tests will use parameters (if applicable) that are in the Self-test Mode Change command (explicit or implied) and/or in the Instrument Configuration Table (ICT).

18.5.4.1.6.1 PIE Functions Self Test

This consists of several sub-tests. A test parameter in the ICT defined which sub-test(s) are performed. This self-test can be called from Power-on, Warm-up, Standby and Fault Modes. The sub-tests are:

- Memory Self-Test

Performs a write/read & compare test on an area of physical memory defined by the test parameters held in the Instrument Configuration Table (ICT). The test aborts after a defined number of errors.

- Processor Self-Test

Performs 'on-line' tests provided by the VPM Firmware which can be performed without affecting the basic functionality of the MHS Instrument, e.g. EDAC, CPU, WD, PCC, BIC.

- Switch TC/TM Self-Test

Tests the operation of the relay commands which are implemented in the Receiver (i.e. channels 1 to 20, see Figure 18.5-56). Each latching relay is commanded into both states, and the corresponding status verified.

If the RFCV is already on when this self-test is selected, it is switched off before starting to operate the switches, otherwise parts of the Receiver would be powered on and off during the test. If the RFCV was on prior to the test, it is switched back on at the end of the test. The test leaves the relays in the same state as before the test.

18.5.4.1.6.2 Fixed Pattern Self Test

Output packets with the data fields set to a fixed binary pattern, as defined by the ICT. This test is used to verify the data transmission to the platform via the 1553 buses.

18.5.4.1.6.3 Watchdog Self Test

The software will enter a continuous loop without resetting the Watchdog timer. This will cause the timer to time-out, causing a CPU hardware reset. This results in the MHS Instrument performing a complete re-initialization, as though entering POWER-ON Mode from OFF Mode. This self-test is therefore 'terminal' for the software. It is intended for ground testing only in order to verify the circuit board link from the timer to the CPU reset line exists.

No packets are generated. Reset of the MHS Instrument processor will occur within 0.7 seconds of selecting the test.

18.5.4.1.6.4 Motor Self Test

The motors are driven and data (either current demand, motor position, RDM/FDM) is stored at each Scan Control Clock. The motor profile can be either one of the predefined scan profiles or a different profile loaded by serial command (using Load Memory command), as selected by the test parameters.

An Extended Tests Data Packet is insufficiently long to include all position data for a full scan period, so a part of the scan period can be selected, according to a test parameter. This parameter defines the COUNT value at which position data is started to be collected.

18.5.4.1.6.5 PRT Calibration Self Test

The software collects data from the PRTs at high frequency. The PRTs are selected as in Scan Mode/Fixed View Mode, i.e. 5 PRTs for approximately 300ms each, plus 3 calibration channels for 300ms each (total time 2.4 seconds). During each 300ms period, the software will read and store the ADC level on each Scan Control Clock (i.e. 120 readings = 277ms), in order to record the time response of the PRT measurement. This will give information on the condition of the PRT and any self-heating effects. The calibration channels only need to be read once, at the end of the 300ms period.

During this self-test mode the motors are not controlled, but the SM heaters are on and the Rx is on to give a representative thermal environment.

18.5.4.1.7 Scan Mode

This is the normal operating mode of the MHS Instrument. In this mode the following activities are taking place :

- The Reflector is performing its nominal scan motion with views of the Earth, Space Calibration Target and On-Board Calibration Target. An error flag indicates if the pointing performance is not being achieved.
- The Flywheel motor is operating, providing momentum compensation.
- The Receiver channels are active with the signals being sampled and processed.
- The science data, including calibration data, OBCT and Receiver temperature data, and MHS Instrument status data are being gathered and assembled into packets and transferred to the MIU upon request.
- HK telemetry is being gathered, monitored and formatted, and is transferred to the MIU upon request.
- The MHS Instrument can receive and respond to commands from the MIU.

This mode is entered from and exited to Standby Mode by serial command. Serial commands to change data tables (ICT, TLT, SCT, DOT) are valid, although changing some of the parameters in this mode will have unpredictable (but safe) results. Requests for HK Telemetry Packets and Science Data Packets are also valid during this mode. All other serial commands are not valid.

18.5.4.1.8 Fixed View Mode

The same activities as Scan Mode are taking place except that the Reflector is not performing the nominal scan but is pointing at a fixed position. The default angular position is 0° (i.e. the OBCT). This can be changed before calling this mode, or during this mode, by serial command. A serial command is also available to instruct the reflector to make a relative step in either direction from its present position (in multiples or sub-multiples of a pixel FOV).

Telemetry indicates the measured Reflector position and a position error flag indicates that it is within the required tolerance of the commanded angle.

Radiometric data is collected at pixel times equivalent to the Earth, Space and OBCT view periods of Scan Mode and placed in the corresponding positions of the Science Data Packet. The Reflector may require up to two seconds to achieve the commanded position. The pixel position data and position error flag in the Science Data packet will indicate when the Reflector is at the commanded position.

This mode is entered from and exited to Standby Mode by serial command. Serial commands to change data tables (ICT, TLT, SCT, DOT) are valid, although changing some of the parameters in this mode will have unpredictable (but safe) results. Requests for HK Telemetry Packets and Science Data Packets are also valid during this mode.

18.5.4.1.9 Safeing Mode

The purpose of this mode is to place the MHS Instrument in a safe configuration in readiness for the removal of power. The Reflector is parked at the OBCT to prevent Sun illumination due to a change in the platform attitude.

Note that power can be safely removed from the MHS Instrument at any time in any Mode, but this will not guarantee that the Reflector is pointing at the OBCT.

Entry into Safe Mode is made in response to the SET MODE 'Safeing' command on the 1553 Command/Telemetry Bus. The mode can be entered from any other powered mode except Fault Mode. The latter mode transition is not implemented because the OBCT is also parked on entry to Fault Mode unless the nature of the fault is such that it may cause damage to operate any part of the scan control elements.

In all modes except Power-On and Warm-up Modes (and Fault Mode), the Scan Mechanism is at operating temperature and the sensors are fully initialized, so the position of the Reflector can be verified and moved to the OBCT if necessary. From Power-on and Warm-up Modes the sensors are not initialized and the motors cannot be operated, so no action is taken.

During this mode, power is removed from the Rx, and the Rx Operational Heaters used, as necessary, to maintain switch-on temperatures.

Safe Mode is a transient mode which automatically exits to Power-on Mode after a minimum of 8/3 seconds. At least one HK Telemetry Packet is generated which indicates Safe Mode is selected. It is expected that Safe Mode activities can always be completed in less then 2 x 8/3 seconds.

18.5.4.1.10 Fault Mode

This mode is entered whenever an anomaly in the MHS Instrument behavior is detected by itself. The configuration of the MHS Instrument is changed to minimize the chance of permanent damage to any part of the MHS Instrument.

The possible ways of entering Fault Mode are:-

- Rx DC/DC Converter (RFCV) secondary power overcurrent detected (by hardware)
- RFCV current (+8V, ±15V) outside 'Fault Level' limits (software monitor)
- Main CV current (5V) outside 'Fault Level' limits (software monitor)
- RDM/FDM current (28V) outside 'Fault Level' limits (software monitor)

- RX/SM/EE/Structure temperature TLM outside 'Fault Level' limits (software monitor)
- Loss of REF CLOCK (and therefore Scan Control Clock) (detected by software).
- Switch Telemetry errors, including PROM Board Segment Switch Errors
- Error during motor position acquisition initialization

The software is collecting current and temperature telemetry at 8/3 second periods. These parameters are checked against two sets of pre-defined limits. One set is called the 'Warning Level' limits, and if any parameter lies outside of these, then the relevant bit of the Fault Code in the HK TLM Packet is set, and the MHS Instrument continues to operate in the same mode. If a parameter lies outside the 'Fault Level' limits, the relevant fault bit is set, and the MHS Instrument automatically enters Fault Mode.

The telemetry checking function can be disabled by writing to the ICT1:4 parameter. This will prevent a transition to Fault Mode. Checking is enabled by default at switch-on.

Fault Mode can also be entered during MHS Instrument configuration changes (mainly during Power-on/Warm-up/Standby mode transitions) if commands are not correctly verified by Switch Telemetry.

The fault bits of the Fault Code are as follows:-

• FDM/RDM motor current trip	The SDA has tripped off due to the current exceeding the hardware trip level (approx 1.6A per motor)
• Current Monitor	A current telemetry lies outside the expected limits
• Thermistor Monitor	A temperature telemetry lies outside the expected limits
• Switch Fault	A switch telemetry does not correspond to its last commanded state
• Processor Fault	A processing fault has occurred e.g. memory EDAC error, overflow, backplane bus transaction error, etc.
• DC Offset Fault	An SPE channel reading is either outside or close to the limits of the dynamic range of the ADC, or the Rx gain is not optimized
• Scan Control Fault	The Reflector position lies outside the acceptable limits with respect to the demanded profile position
• REF Clock Fault	The platform Reference Clock is not present. Science functions cannot be performed and the Instrument is not synchronized.

Refer to section 18.5.6.4.4 for a fuller description of these bits.

The actions taken in Fault Mode depend on the cause of the fault. In all cases, the Receiver is turned off and the motor drive circuits disabled. If the fault is due to a RFCV H/W overcurrent, RFCV current monitor, Rx or Structure (not SSHM) temperature monitor, then the Reflector is parked at the OBCT before disabling the motor drive circuits. If the fault is due to a 5V current monitor or a SM, SSHM or EE temperature monitor, then the SPE/SCE/SSHM functions are turned off.

Once these actions have been taken, Fault Mode is very similar to Power-on Mode. Diagnostic procedures can be carried out using serial commands to control specific switches, read specific telemetry, and perform memory load and memory read operations. Note that if a self-test routine is required, Power-on Mode must first be selected.

Fault Mode is exited by serial command to Power-on Mode. It may be necessary to change a parameter in the Telemetry Limits Table (TLT), if considered safe, or the Instrument Configuration Table (ICT) before doing this, in order to prevent a transition back to Fault Mode.

18.5.4.1.11 Overcurrent Mode

This mode is entered when an overcurrent condition is detected by the Main DC/DC converter, which supplies power to the EE. This can occur in any powered mode and is detected automatically by hardware.

When the current on a Main Converter secondary power line exceeds a predefined limit, perhaps due to a component failure in the EE, the converter is immediately disabled, resulting in all its secondary outputs falling to zero volts.

The EE is therefore switched off and all MHS Instrument software activities stop. In addition, the Rx converter is also disabled, if operating at the time. Note that the Main and Pulsed Load Buses are still active. Detection of this condition can be made by either using the spacecraft primary bus current telemetry or due to the lack of responses (HK, SD or serial command) on the 1553 A or B buses. To restart the MHS Instrument, the MHS Main Power Bus must be switched off, causing a transition to OFF Mode, from which power is reapplied to enter Power-on Mode. Power may be applied to the other MHS Main Power Bus in order to select the PIE redundancy which may prevent a reoccurrence of the fault. Note that the SPE and SCE circuits are not switched on automatically on entry to Power-on Mode in case the fault is in these circuits.

18.5.4.2 Scan Control

18.5.4.2.1 General Description

The Scan Control functions of the instrument control the motion of the Reflector via the Reflector Drive Module (RDM) and the momentum compensation Flywheel via the Flywheel Drive module (FDM).

The Scan Control functions according to Instrument mode are:

<table>
<tr><td>Mode</td><td>RDM (Reflector)</td><td>FDM (Flywheel)</td></tr>
<tr><td>Power-on</td><td>motors are off</td><td>motors are off</td></tr>
<tr><td>Warm-up</td><td>motors are off</td><td>motors are off</td></tr>
<tr><td>Standby</td><td>actively held pointing at OBCT</td><td rowspan="6">copies the motion of the RDM</td></tr>
<tr><td>Scan</td><td>performs the scan profile with an Earth View, Space View and OBCT View.</td></tr>
<tr><td>Fixed View</td><td>actively held pointing at the requested position</td></tr>
<tr><td>Safeing</td><td>moved to OBCT then switched off</td></tr>
<tr><td>Fault</td><td>moved to OBCT then switched off, provided the fault is not related to any part of the scan control functions</td></tr>
<tr><td>Self-test</td><td>depends on type of self-test</td></tr>
</table>

In normal operation, the Flywheel is made to copy the Reflector motion but in the opposite direction such that it compensates the momentum and torque perturbations caused by the Reflector motion.

In Power-on and Warm-up Modes the motors drives are off and so the motor current is zero and hence the Reflector and Flywheel positions are undefined and uncontrolled. There are no clamping devices on the motors, but the motors will remain stationary due to the magnetic slots of the motor and bearing friction, unless an external force is applied.

18.5.4.2.2 Initialization and RDM/FDM Enabling and Disabling

On the transition from Warm-up Mode to Standby Mode, the motor drives are switched on and an initialisation sequence starts. Both motors rotate at a constant velocity (nominally 60°/s, although this can be changed by changing data reference 2:1 of the Scan Control Table before requesting the mode transition to Standby from Warm-up) for a minimum of 2 revolutions and a maximum of 3 revolutions (i.e. a maximum duration of about 11 seconds). This is done in order to correctly initialise the position measurement system using the Inductosyn and Zero Position sensors. When this is successfully completed, the Reflector is parked at the OBCT position, and is actively held at this position by the scan control system.

It is possible to disabled one or both motors (i.e. RDM and/or FDM). This is not expected to be done during nominal operation, but may be required during a diagnostic sequence. It also allows the Instrument to continue to be used with the RDM only, in the event of an FDM failure.

Enabling and disabling is achieved in three ways:-

- Instrument Configuration Table (ICT). ICT3:1 and 3:2 define the configuration to be used when performing the Warm-up to Standby Mode transition. This is the recommended means of controlling the motor's configuration, as it ensures correct initialization of the scan control system.

- Switch Command channels 3:8 (FDM Motor Supply on/off) and 3:9 (FDM Motor Supply on/off). These commands will take immediate effect providing the Instrument is in a mode where the motors are normally active. If performed in an inactive mode, they will be overridden by the ICT when the Warm-up to Standby Mode transition is done. Note that re-enabling a motor that was not enabled on the Warm-up to Standby Mode transition will cause unexpected position and torque transients. This is not recommended.
- On entry to Motor Self-Test Mode, the motor configuration is defined by ICT8:1.

If the FDM is disabled then the RDM will continue to operate normally. If the RDM is disabled and the FDM left enabled, the FDM will only move if the RDM is moved by some external force.

If a Warm-up to Standby Mode transition is attempted with the RDM motor drive disabled, the sensor initialization cannot be achieved and the software will timeout and enter Fault Mode. If the RDM is enabled and the FDM disabled, then the RDM will be correctly initialized and the transition to Standby Mode completed, but the FDM position measurement will not be correctly initialized.

18.5.4.2.3 Scan Profile

In Scan Mode, the Reflector performs the Scan Profile. This is a predefined position versus time profile which incorporates the Earth View and the two calibration targets. Three predefined profiles are provided; Profiles 0, 1 and 2, and these are the same except for small changes in the position of the Space View. There is also provision for modifying part of or the whole of a profile by telecommand.

The 'Profile Table' is an area of memory which holds the current Scan Profile. It is a look-up table which defines both position and acceleration parameters against time, as required by the control algorithm. The Profile Table is calculated on the Warm-up to Standby Mode transition. The Profile parameter, SCT3:1, defines which profile will be calculated. This parameter indicates which set of calculation parameters held in the SCT will be used to calculate the contents of the Profile Table:-

Profile = 0; profile calculation parameters = SCT51..59
Profile = 1; profile calculation parameters = SCT60..68
Profile = 2; profile calculation parameters = SCT69..77.

The calculation parameters define time segments with associated acceleration, deceleration and constant velocity values. Note that the time parameters corresponding the Earth, Space and OBCT view must be divisible by 8 so that the pixel collection can be synchronized to the scan profile.

The Profile Table can be partially or wholly changed in Standby Mode using Load Memory Commands. If this is performed is it recommended that the Profile parameter (when SCT3:1) is set to '3' to indicate in telemetry that a non-standard profile is being used, and also to ensure the modified Profile Table is not rewritten on the next Warm-up to Standby transition (if Profile=3 then no calculations are performed and the contents of the Profile Table remain unchanged). The Profile Table can also be modified in Power-on and Warm-up Modes, in which case Profile=3 must be set to ensure it is not rewritten on the transition into Standby.

The standard profiles, held in PROM, are as follows:-

	Profile 0	Profile 1	Profile 2
Earth View	130° to 230°		
OBCT View centre	0°		
Space View centre	253.6°	(253.6 - 4 pixels) =249.1555°	(253.6° + 4 pixels) =258.04444°

Where 180° = Nadir, 1 pixel = 10/9° = 1.1111°
The calibration views are 4 pixels wide (4.4444°)

18.5.4.3 Radiometric Data Acquisition

Radiometric signals are acquired by the Rx and digitized by the EE. The following points affect the performance of the data acquisition system.

- Rx Gain

Following switch-on, the Rx baseband amplifier gains are reset to their minimum value (0dB). Over life, the overall Rx gain reduces and this can be compensated for by increasing the baseband gain (+1dB, +2dB, +3dB). This results in a better use of the SPE dynamic range and achieves optimum linearity performance. It will normally be known what the required gains are, and these can be programmed into the ICT (by telecommand) so that the correct gains are set when the Rx is switched on (Power-on to Warm-up Mode transition). Normal inspection of the Science Data during operation in Scan Mode will indicate if the signal dynamic range is approaching the minimum acceptable value, thereby indicating a change in gain is advisable.

- SPE DAC Offsets

The SPE DAC offsets are initialized to the default values held in PROM following switch-on. Again, these values are largely dependent on the Rx ageing process and their current optimum values will be known at any given time. If these values are significantly different to the PROM default values then reprogramming their values after a switch-on will result in good science data as soon as Scan Mode is selected. Alternatively, the DAC Offset values can be updated by telecommand while in Scan Mode.

As a third option, if the correct DAC Offset values are not known, Automatic DC Offset Mode can be selected (ICT 0:3) and this will set the correct values after several scan periods in Scan Mode. It is recommended that Manual DC Offset is then reselected to avoid further changes to the values during operation. Normal inspection of the Science Data during operation in Scan Mode will indicate if the SPE signal is approaching a saturation limit thereby indicating a change in DAC offset is advisable.
(Note that a single lsb change of the DAC Offset value results in a 1670 lsb change (1708 for MHS EM) in the SPE output value. If Automatic DAC Offset is left enabled, changes in multiples of 1670 (1708 EM) lsb will occur on the SPE output if the output value nears the dynamic range limits.)

- SPE Gain

The SPE Gain is a fixed value, but can vary by a few percent from model to model. The optimum value for the model can be programmed on initialization using the appropriate telecommand. This value is only used when Automatic DC Offset Mode is selected, and using the optimum value will result in the signal being centered in the dynamic range to better accuracy than with a non-optimized value.

18.5.4.4 Fault Handling

The Instrument software performs a telemetry monitoring function which checks the health of the Instrument. If a minor anomaly is detected, then an appropriate Fault Flag is raised in the HK Telemetry (HK packet and SD packet). If a more significant anomaly or fault is detected, then the Instrument ceases the current mode of operation and enters Fault Mode. Actions are taken to minimize any risk of damage to the Instrument, according to the nature of the fault.

Part or all of the telemetry monitoring functions can be disabled by writing to ICT:1:4.

An overcurrent fault on the secondary supplies to the main processing electronics (PIE) will cause the Main DC/DC Converter to trip off and the entire Instrument will turn off (OverCurrent Mode).

18.5.4.5 Redundancy Handling

- PIE A/B

The PIE redundancy is selected by the Main Bus (e.g. if Main Bus A is selected, then PIE A is selected). Refer to section 18.5.4.1.3 and Figure 18.5-46 for a fuller description.

- 1553 Busses A/B

Both the Cmd/Tlm bus and the Science Data Bus have redundancy. This is fully cross-strapped with the PIE redundancy. The redundancy is selected according to the MIL-STD 1553 definition (i.e. the Remote Terminal (MHS Instrument) responds on the same bus that the command arrived on).

• Receiver H1..H5 channels Local Oscillators (LOs) A/B
The LO (i.e. QBS) redundancies are selected by the internal commands "Hn Select LO A/B". These can be issued directly using the Switch Command. In addition, the MINOS issues these commands automatically to select the redundancy in accordance with the ICT (ICT1) on the Power-on to Warm-up Mode transition.

• Zero Position Sensors A/B
The zero position sensor redundancies for the RDM and FDM are selected by the internal commands "RDM/FDM Select Zero Position A/B". These can be issued directly using the Switch Command. In addition, the MINOS issues these commands automatically to select the redundancy in accordance with the ICT (ICT1) on the Warm-up to Standby Mode transition.

• Motor Commutation Sensors A/B
The motor commutation sensor redundancies for the RDM and FDM are selected by the internal commands "RDM/FDM Motor Sensors A/B". These can be issued directly using the Switch Command. In addition, the MINOS issues these commands automatically to select the redundancy in accordance with the ICT (ICT3) on the Warm-up to Standby Mode transition.

• SPE Channels 1..5 (nominal) and SPE channel 6 (redundant)
The SPE redundant channel (SPE6) can be used to replace any one of the 5 nominal channels. This is achieved by using the internal commands (SPE Mux Code 3:1, 3:2, 3:3). These can be issued directly using the Switch Command. In addition, the MINOS issues these commands automatically to select the redundancy in accordance with the ICT (ICT3:1) on the Warm-up to Standby Mode transition.

18.5.4.6 Software Parameter Tables

The MHS Instrument has 4 tables of parameters which are used to determine the detailed behavior of the instrument. These tables are:-

Instrument Configuration Table	ICT	36 octets
Telemetry Limits Table	TLT	396 octets
Scan Control Table	SCT	360 octets
DC Offsets Table	DOT	16 octets

These tables are stored in PROM and hold the default values. These default values are copied in to RAM at power-on initialization for use during operation. The value of any parameter can be changed during operation by sending a 'Load Table Data' command on the Command/telemetry Bus.

The format of the tables is given in Appendices A to D. The instrument serial number unique initialization parameters are given in Appendix E.

The format is specific to each table and depends on the data type of the parameter. Some parameters are floating point values (4 octets), some are integers (one octet, two octets), some are fixed point (an integer with a scaling constant) and some are control flags (single bits, with up to 8 flags concatenated into a single octet).

The Load Table Command changes a block of 4 octets simultaneously, so in some cases many parameters can be changed at the same time. The command defines which table and which block ('Data Reference') is to be changed, and the new data.

Refer to the introduction to each Appendix for a description of the table usage and parameter usage. A summary is provided in the following sections.

18.5.4.6.1 Instrument Configuration Table (ICT)

This table can be divided into two parts:

- Data Ref 0 to 3 = Instrument Configuration control
- Data Ref 4 to 8 = Self-test routine parameters

Data Ref 0	several control flags which allow automatic functions to be turned on/off.
Data Refs 1,2 & 3	provide control flags to indicate the configuration of internal command channels. Note that the Receiver commands (1:1 to 1:37) are set up on the Power-on to Warm-up Mode transition, and the BIM commands (3:1 to 3:11) are set up on the Warm-up to Standby Mode transition.
Data Ref 2	indicates which Operational Heaters to use for the Receiver (i.e. Rx Op Heaters or Aux Op Heaters).
Data Ref 4 to 8	Self-test routine parameters should be self explanatory after reference to self-test mode descriptions

18.5.4.6.2 Telemetry limits Table (TLT)

Refer to notes in Appendix B.

This table provides warning and fault levels for:

- thermistor telemetry : for each mode of operation (Data Refs 1..72)
- current telemetry : for each mode of operation (Data Refs 86..99)

It also provides parameters which control when the two automatic mode transitions occur (Power-on to Warm-up, Warm-up to Standby):

- thermistor telemetry (Data refs 73..84)
- timeout values (Data Ref 85).

18.5.4.6.3 Scan Control Table (SCT)

The only Data Ref required during nominal operation is Data Ref 3 (Profile type) other than changes which are performed by command at initialization, as defined by section 5.

Data Refs 0:1, 0:2, 6, 7, 29, 30 define the characteristics of the Scan Drive Amplifier in the EE to allow optimization of control.

Data Ref 0:3 provide control flags for enabling and disabling the ripple torque and cogging torque correction terms of the control algorithms.

Data Ref 0:4 defines a delay parameter which allows the current demand output to be delayed by a number of control clock periods to allow assessment of the control stability during ground testing.

Data Ref 1 defines the allowed tolerance of the control error (demanded position - actual position). If the control error exceeds these values during radiometric data measurement periods, an error flag is raised in the HK telemetry and Science Data Packets.

Data Ref 2 defines the speed of rotation used when the motor position sensors are being initialized (on Warm-up to Standby Mode transition).

Data Ref 3 defines which type of profile the Reflector performs. The software uses a look-up table (called the Profile Table) which defines the position versus time of the Reflector. Profile 0 is the nominal profile, Profile 1 corresponds to the Space View moved 4.44° closer to the Earth View and Profile 2 corresponds to the Space View moved 4.44° closer to the OBCT. If Profile 3 is defined, no profile is calculated and it is the ground control responsibility to load a valid profile into the software Profile Table.

Data Refs 4 to 26, 78 to 81, 84, 85, 87 to 101 are parameters which affect the control characteristics of the RDM.

Data Refs 27 to 50, 82, 83, 86 are parameters which affect the control characteristics of the FDM.

Data Refs 51 to 77 are parameters which define the shape of Profiles 0, 1 and 2. These parameters must be updated in Power-on Mode or Warm-up Mode because the MHS Instrument software will recalculate the Profile Table on the Warm-up to Standby Mode transition. If none of the 3 profiles are what is required, these parameters are not used, and the Profile Table must be loaded manually, element by element, by serial command (and Data Ref 3 must be set to '3').

18.5.4.6.4 DC Offsets Table (DOT)

This table provides parameters which are used to keep the radiometric input signal within the dynamic range of the ADC in the EE.

Data Refs 0:1 to 1:1 define the value of the DAC which removes the DC component of the radiometric signal. These values are used when manual control of the DC offset is selected (See ICT Data Ref 0) and at initialization when automatic control is selected.

The remaining parameters are related to automatic control of the DC offset, and define the gain of the amplifier chain, the ideal operating point, upper and lower deadbands and allowable dynamic range.

18.5.5 INTERFACE TIMING

18.5.5.1 General

All MHS interfaces with the spacecraft are via the MIU as shown in Figure 18.5-9.

18.5.5.2 Clock

The MIU provides redundant Reference Clock (A, B) outputs to the MHS. The electrical characteristics of the clock are shown below.

- Signal type: Constant frequency square wave (Coherent with spacecraft 1.248MHz clock)
- Frequency: 1048576 ± 10 Hertz
- Duty Cycle: 50 ± 5 % of period

All internal timing of the MHS is derived from this clock.

18.5.5.3 Synchronization Signal

The MIU shall provide redundant 8 second synchronization pulse outputs to the MHS. The electrical characteristics of the synchronization pulse are shown below.

- Signal type Constant frequency
- Period 8 Seconds
- Logic ON pulse width 258.4 ± 18 microseconds.

The 8 second pulse synchronizes the MHS scan and output data to the start of the space-craft AMSU Information Processor (AIP) frame.

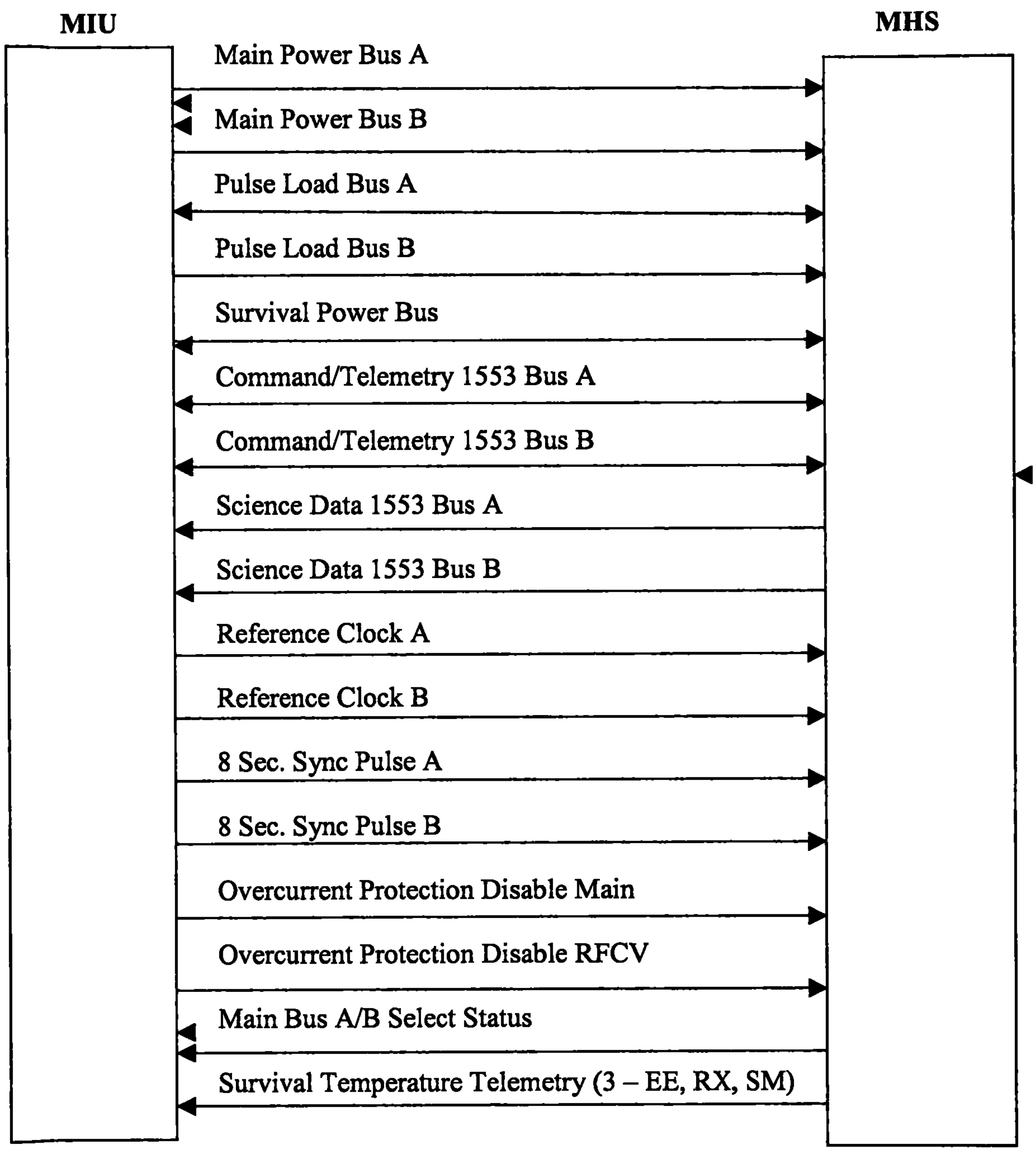

Figure 18.5-9. MHS/MIU Interface

18.5.6 INSTRUMENT TELEMETRY

18.5.6.1 Analog Telemetry

Three survival temperature thermistors provided by the MHS are conditioned in the MIU for insertion in the Telemetry Information Processor (TIP) 16 second subcom. This telemetry is as shown in Figure 18.5-10.

.	Telemetry Point Name	Range °C	CH. # (Subcom)
1	Electronics Equipment (EE) Temperature	-60 to + 65	16AN 16 317 (16-1)
2	Receiver (RX) Temperature	-60 to + 65	16AN 17 333 (16-1)
3	Scan Mechanism (SM) Temperature	-60 to + 65	16AN 80 365 (16-1)

Figure 18.5-10. MHS Analog Telemetry.

18.5.6.2 Digital "B" Telemetry

Digital "B" Telemetry is a one bit status indicator inserted in the TIP 3.2 second subcom.
The MHS related status telemetry is as shown in Figure 18.5-11.

No.	Telemetry Point Name	Logic "1"	Logic "0"	Channel No.
1	MHS Survival Heater	ON	OFF	126
2	RF Converter Protect Disable	NO	YES	166
3	MHS Power B	ON	OFF	182
4	MHS Power A	ON	OFF	187
5	Main Converter Protect Disable	NO	YES	190
6	MIU Main Bus Select (1)	A	B	191

(1) Telemetry source is from MHS; all others are derived in the MIU.

Figure 18.5-11. MHS Digital "B" Telemetry.

18.5.6.3 Digital "A" Telemetry

Command, monitoring and scientific data retrieval of the MHS is achieved using two MIL-STD 1553 serial buses:-

- Command/Telemetry Bus (CT Bus)
- Science Data Bus (SD Bus).

All messages on these buses are formatted as CCSDS packets. A description of the CCSDS packet format may be found in Appendix F.

The MIU is the Central Terminal for the 1553 busses and, in normal operation, will perform the following 1553 actions during each 8/3 (2.667) second Scan Period:

- issue a 'Request HK Packet' over the CT Bus
- collect the HK Packet over the CT Bus
- issue a 'Request SD Packet' over the SD Bus
- collect the SD Packet over the SD Bus
- issue a MHS Command Packet if a command is pending

The MIU transfers the MHS HK packet data to the TIP each scan period; the data are inserted in the TIP Minor Frame word 102 (AIP 205). The MHS data are inserted in the TIP Minor Frames as shown in Figure 18.5-12. Refer to Programming and Control Handbook Section 5 for the TIP Orbital Mode telemetry format.

TIP Minor Frame (1)	# Words (Octets)	Parameter
7-10	4	Scan 2 Coarse Time Code (2)
11-12	2	Scan 2 Fine Time Code (2)
13-28	16	Scan 2 Housekeeping Telemetry (2)
33-36	4	Scan 0 Coarse Time Code
37-38	2	Scan 0 Fine Time Code
39-54	16	Scan 0 Housekeeping Telemetry
59-62	4	Scan 1 Coarse Time Code
63-64	2	Scan 1 Fine Time Code
65-80	16	Scan 1 Housekeeping Telemetry

(1) The table data is modulo 80, i.e. the next Scan 2 starts in Minor Frame 87.
(2) Scan 2 is the last scan of the previous 8 Second Period

Figure 18.5-12. CT Bus Telemetry Commutation in TIP Frame.

The MIU transfers the MHS SD packet data to the AIP each scan period; the data are inserted in the AIP frame words 48 through 97. The MHS data are inserted in the AIP Frame as shown in Figure 18.5-13. Refer to Programming and Control Handbook Section 7 for the AIP Output Telemetry Format.

The CT Bus HK data may be replaced by either a Test Data Packet or Memory Data Packet depending on the Instrument mode (Self-Test) or in response to ground command. Similarly, the SD Bus SD data may be replaced by either an Extended Test Data Packet or Extended Memory Data Packet depending on the Instrument mode (Self-Test) or in response to ground command. A description of the CT and SD Bus packet data is given in the following sections.

MIU Minor Cycle(1)	AIP Word	Parameter
0	90-97	Scan 2 Science Packet Data (2)
1-25	48-97	Scan 2 Science Packet Data (2)
26	48-81	Scan 2 Science packet Data (2)
27	74-97	Scan 0 Science Packet Data
28-52	48-97	Scan 0 Science Packet Data
53	48-65	Scan 0 Science Packet Data
54	56-97	Scan 1 Science Packet Data
55-79	48-97	Scan 1 Science Packet Data

(1) The MIU Minor Cycle Count is contained in AIP Word 7.
(2) Scan 2 is the last scan of the previous 8 Second Period

Figure 18.5-13. SD Bus Data Commutation in AIP TIP Frame.

18.5.6.4 CT Bus Housekeeping Packet

MHS generates a Housekeeping Packet every Scan Period (2.6667 sec). The HK Packet complies with the CCSDS standard and is 30 octets long. A summary of the format is shown in Figure 18.5-14.

Octet	Reference	Field Name
1 to 6	App. F (1)	CCSDS Primary Header (Application ID, Packet Sequence Count)
7 to 12	18.5.6.4.1	CCSDS Secondary Header (Time Code) (2)
13	18.5.6.4.2	MHS Mode Code/PIE ID/Sub Commutation Code (2)
14 to 17	18.5.6.4.3	Telecommand Acknowledgement Field (2)
18	18.5.6.4.4	Fault Code (2)
19 to 21	18.5.6.4.5	Switch Status Telemetry (2)
22 to 25	18.5.6.4.6	Thermistor Telemetry (2)
26 to 28	18.5.6.4.7	Current/Power Telemetry
29,30	App. F (1)	Checksum

(1) The Primary Header and Checksum are not transferred from the MIU to the TIP. Consequently a total of 22 octets of data from each MHS scan are inserted in TIP Word 102 (AIP 205) as shown previously in Figure 18.5-12. Refer to Appendix F for CCSDS Packet Format

(2) This data in the HK Packet is also available in the Science Data Packet (see Figure 18.5-32).

Figure 18.5-14. Summary of HK Packet Format.

A summary of the data in an HK Packet is given in Table 18.5.15. Full details are provided in the Reference sections.

Reference	Parameter Name
App. F	CCSDS Packet Version
	CCSDS Packet Type
	Secondary Header Flag
	Application Process
	Segment Flags
	Source Sequence Count
	Packet Length
18.5.6.4.1	Coarse Time Code
	Fine Time Code
18.5.6.4.2	Mode Code
	PIE ID
	Sub-commutation Code
	Self-Test Code
18.5.6.4.3	TC Acknowledgement: TC Clean Flag
	TC Acknowledgement: TC Conforms Flag
	TC Acknowledgement: TC Recognized Flag
	TC Acknowledgement: TC Legal Flag
	TC Acknowledgement: TC Application ID
	TC Acknowledgement: TC Packet Sequence
	TC Acknowledgement: TC Received Count
18.5.6.4.4	Fault Code: Current Monitor
	Fault Code: Thermistor Monitor
	Fault Code: Switch Fault
	Fault Code: Processor Fault
	Fault Code: DC Offset Error
	Fault Code: Scan Control Error
	Fault Code: Ref Clock Error
	Fault Code: RDM Motor Trip
	Fault Code: FDM Motor Trip
	Fault Code: PROM Switch Error
18.5.6.4.5	Switch Status Telemetry:- • TM1:1 to TM1:11 • TM2:1 to TM2:4 • TM3:4 to TM3:11

Refer to Reference Sections for definition of TMn:m channel numbers.

Figure 18.5-15. Summary of Telemetry Parameters in an HK Packet.

18.5.6.4.6	Thermistor Telemetry (sub-commutated):- • TM4:1 to TM4:4 (when Sub-commutation Code=1) • TM4:5 to TM4:8 (when Sub-commutation Code=2) • TM4:9 to TM4:12 (when Sub-commutation Code=3) • TM4:13 to TM4:16 (when Sub-commutation Code=4) • TM4:17 to TM4:19, TM4:24 (when Sub-commutation Code=5) • TM4:20 to TM4:23 (when Sub-commutation Code=6) • TM6:2 to TM6:5 (when Sub-commutation Code=7)
18.5.6.4.7	+5V current (TM5:3)
	Rx Global power (TM5:4,TM5:5,TM5:6)
	Total Motor Current (TM5:1+TM5:2)
App. F	Checksum

Refer to Reference Sections for definition of TMn:m channel numbers.

Figure 18.5-15. Summary of Telemetry Parameters in an HK Packet (continued).

18.5.6.4.1 Time Code

The time code indicates the time corresponding to the start of Earth Scan of the scan revolution for which the data applies. In general this will be a time value that will become valid at the next occurrence of the 8SP clock.

The coarse time code will contain a count of the number of seconds elapsed since the epoch, and the fine time shall contain the fractions of seconds since the last increment of the coarse field as shown in Figure 18.5-16. Refer to Set Time Code command, Section 18.5.7.3.6 for details of the implied epoch.

Subfield Name	Size (octets)	Description
Coarse Time Code	4	1 LSB = 1 second
Fine Time Code	2	1 LSB = 2^{-16} seconds

Figure 18.5-16. Time Code Format.

18.5.6.4.2 MHS Mode Code/PIE ID/ Sub Commutation Code

The Mode and Sub-commutation Code format is as shown in Figures 18.5-17.

MSB							LSB
Mode Code				PIE ID	Sub-commutation Code		

Figure 18.5-17. Mode and Sub-Commutation Field.

The Mode Code identifies the current operating mode, as shown in Figure 18.5-18.

Mode Field	Code
Power-on	0000
Warm-up	0001
Standby	0010
Scan	0011
Fixed View	0100
Self-test	0101
Safeing	0110
Fault	0111
Unused	1000 .. 1110
Memory Data Packet ID	1111

Figure 18.5-18. Mode Parameter Definition.

The Mode Code is changed following successful completion of a mode transition, except for transitions to Fault Mode when the Mode Code is changed as soon as the fault is detected.

The Mode Code implies the type of packet. All mode codes except 0101 and 1111 imply that the packet is a HK Telemetry Packet. Code 0101 implies a Test Packet, and Code 1111 implies a Memory Data Packet.

The PIE identify bit indicates which PIE is active, 0 = PIE A, 1 = PIE B

The sub commutation Code indicates which set of thermistor telemetry data is included in this packet, as defined in Figures 18.5-25 and 18.5-26. The sub commutation Code is incremented each time a HK Telemetry Packet is sent.

18.5.6.4.3 Telecommand Acknowledgement Field

The TC Acknowledgment and Fault Code field is shown in Figure 18.5-19.

<table>
<tr><td>MSB</td><td></td><td></td><td></td><td></td><td></td><td></td><td>LSB</td></tr>
<tr><td>TC Clean</td><td>TC Con-forms</td><td>TC Recogniz ed</td><td>TC Legal</td><td>FDM Motor Current Trip Status</td><td colspan="3">TC Application ID</td></tr>
<tr><td colspan="8">TC Application ID</td></tr>
<tr><td colspan="8">TC Packet Sequence</td></tr>
<tr><td colspan="6">TC Packet Sequence</td><td colspan="2">TC Received Count</td></tr>
</table>

Figure 18.5-19. Telecommand Acknowledgement Field.

The 'TC Clean Flag' will be set to a '1' if a parity or a checksum error is not found in the received packet.

The 'TC Conforms Flag' will be set to a '1' if the header of the received command conforms to the CCSDS format.

The 'TC Recognised Flag' will be set to a '1' if the received command is a recognised MHS command of the correct format.

The 'TC Legal Flag' will be set to a '1' if the received command is legal for execution in the current MHS operating mode.

The 'TC Application Process ID' is taken from the Packet ID field of the primary header of the received Serial Command.

'FDM Motor Current Trip Status' : see RDM Motor Current Trip Status below.

The 'TC Packet Sequence Count' is the Source Sequence Count taken from the Packet Sequence Control field of the primary header of the received Serial Command (see Appendix F).

All of the above fields (except FDM Motor current Trip Status) will be set when a Serial Command (received on the Cmd/Tlm Bus) is processed. If a second Serial Command is received in the period of the same Housekeeping Telemetry packet, then no field will be overwritten. The second (and subsequent commands) will be acknowledged ONLY in the TC Received Count.

The 'TC Received Count' is the count of all valid (i.e. accepted for execution) Serial Commands received since the last Housekeeping Telemetry packet was transmitted. This count is limited to three, i.e. it will not roll over.

The TC Acknowledgement field in the HK Telemetry Packet which is transmitted on the Cmd/Tlm Bus is used to acknowledge commands received on the Cmd/Tlm Bus only. Commands received on the Science Data Bus are acknowledged in the TC Acknowledgement field of the Full HK Telemetry Field which is included in packets transmitted on the Science Data Bus.

Housekeeping Telemetry Packets will be generated internally at the same rate as a frame of telemetry is collected. Results from the frame collection will also be included in the packet.

18.5.6.4.4 Fault Code Field

The Fault Code field is shown in Figure 18.5-20. The Fault Code is latched on entry to Fault Mode and reset on exit from Fault Mode.

Current Monitor Fault	Thermis-tor Monitor Fault	Switch Fault	Process-or Fault	RDM Motor Current Trip Status	DC Offset Error	Scan Control Error	REF Clock Error

Figure 18.5-20. Fault Code Field.

The 'Current Monitor Fault' bit will be set to a '1' when any of the Power Supply Electronics (PSE) Current monitor parameters exceeds its expected limits.

The 'Thermistor Monitor Fault' bit will be set to a '1' when any of the Thermistor temperature monitor parameters listed in Section 18.5.6.4.6 is outside of its expected limits.

For Housekeeping telemetry, this flag will be set if it is one of the four multiplexed values that are in error; if a value is outside limits, but not included in the packet, then this bit will not be set. For Science Data packets, all temperature values are included in all packets, so this bit will be set whenever any value is outside expected limits.

The 'Switch Fault' bit will be set to a '1' when a switch status telemetry parameter does not agree with its last commanded state, or a PROM board switch error has occurred.

The 'Processor Fault' bit will be set to a '1' after a processor internal fault has occurred (overflow, illegal address, BIT failure).

The 'RDM (or FDM) Motor Current Trip Status' will be set to a '1' when the instantaneous current in the respective motor has exceeded a preset level, resulting in the disabling of the respective motor drive circuit. These bits correspond to the inverse of the Telemetry Channels 3:12 and 3:13 (see Figure18.5-24).

The 'DC Offset Error' bit will be set to a '1' when any of the channel calibration targets readings indicate a change in the DC offset is required. This bit will be set only in Scan Mode when the calibration targets are sampled.

The 'Scan Control Error' bit will be set to a '1' if the measured mid-pixel position of the reflector during Earth, Space or OBCT views is outside the limits for the Scan Mode profile, or the reflector position is outside the limits of the requested position for Fixed View Mode, or the position acquisition initialization has failed

The 'REF CK Error' bit will be set if the Scan Control Clock stops as a result of an interruption of the MIU Reference Clock.

18.5.6..4.5 Switch Status Telemetry

Switch Status Telemetry consists of Switch Closure (HL Commands verification), Bilevel Status (Steady State Commands verification) and BIM Register (BIM Register Commands verification) channels respectively.

The Switch Status field gives the latest values of all Contact Parameters acquired from the Internal Telemetry interface. The format of this field is as shown in Figure 18.5-21.

MSB							LSB
1:8	1:7	1:6	1:5	1:4	1:3	1:2	1:1
PROM	2:4	2:3	2:2	2:1	1:11	1:10	1:9
3:11	3:10	3:9	3:8	3:7	3:6	3:5	3:4

Figure 18.5-21. Switch Status Field.

The channel number codes of the telemetry parameters are cross referenced to the actual parameter in Figures 18.5-22, 18.5-23 and 18.5-24 below in this section.

Telemetry channels 3:1, 3:2 and 3:3 are not reported in the HK Telemetry Packet but appear in the Signal Processing Status Field (SPE MUX CODE) of the Science Data Packet.

Telemetry Channels 3:12 and 3:13 are not reported in this field but appear in the Telecommand Acknowledgement and Fault Code Field of the HK Telemetry Packet (called RDM and FDM Motor Current Trip Status)

PROM is set when a PROM segment switch has failed ON.

MHS Channel Number	Parameter Name	Status	Tlm Source
1:1	Receiver Channel H1 On/Off	0=Off	Rx
1:2	Receiver Channel H1 Local Oscillator A/B selected	0=A	Rx
1:3	Receiver Channel H2 On/Off	0=Off	Rx
1:4	Receiver Channel H2 Local Oscillator A/B selected	0=A	Rx
1:5	Receiver Channels H3/H4 Frontend On/Off	0=Off	Rx
1:6	Receiver Channel H3/H4 Local Oscillator A/B selected	0=A	Rx
1:7	Receiver Channel H3 Backend On/Off	0=Off	Rx
1:8	Receiver Channel H4 Backend On/Off	0=Off	Rx
1:9	Receiver Channel H5 On/Off	0=Off	Rx
1:10	Receiver Channel H5 Local Oscillator A/B selected	0=A	Rx
1:11	RX CV On/Off	0=Off	EE

Figure 18.5-22. Switch Closure Telemetry Channels.

MHS Channel Number	Parameter Name	Status	Tlm Source
2:1	Receiver Operational Heaters On/Off	0=Off	EE
2:2	Scan Mechanism Operational Heaters On/Off	0=Off	EE
2:3	Auxiliary Operational Heaters On/Off	0=Off	EE
2:4	Signal Processing Electronics/Scan Control Electronics On/Off	0=Off	EE

Figure 18.5-23. Bilevel Status Telemetry Channels.

MHS Channel Number	Parameter Name	Status	Telemetry Source
3:1	SPE MUX CODE (1)	MSB	
3:2	SPE MUX CODE (1)		
3:3	SPE MUX CODE (1)	LSB	
3:4	RDM Zero Position Sensors A/B selected	0=A	EE
3:5	FDM Zero Position Sensors A/B selected	0=A	EE
3:6	RDM Motor Sensors A/B selected	0=A	EE
3:7	FDM Motor Sensors A/B selected	0=A	EE
3:8	RDM Motor Supply On/Off	0=Off	EE
3:9	FDM Motor Supply On/Off	0=Off	EE
3:10	RDM Motor Current Trip Enable/Disable Status	0=enabled	EE
3:11	FDM Motor Current Trip Enable/Disable Status	0=enabled	EE
3:12	RDM Motor Current Trip Status	0=trip detected	EE
3:13	FDM Motor Current Trip Status	0=trip detected	EE

(1) SPE MUX CODE not included in HK packet, refer to 18.5.6.7.3.

Figure 18.5-24. BIM Register Telemetry Channels.

18.5.6.4.6 Thermistor Telemetry

The Temperature Data Field of each packet will contain four thermistor telemetry channel parameters. Each packet will contain a pre-defined sub-commutated group of values, from either the Standard Precision Thermistor instrument monitors (8-bit), or from the High Precision Temperature (OBCT) monitors (12-bit). Figure 18.5-25 lists the thermistor telemetry channels for general monitoring of the temperature of instrument hardware.

The high-precision Platinum Resistance Thermometer (PRT) temperature sensors are used to accurately monitor the On-Board Calibration Target. The values that are sub-commutated into the Housekeeping Telemetry packets are truncated to 8-bits, but the full 12-bit range is included in the Science Data packets. Figure 18.5-26 lists the PRT temperature telemetry channels.

MHS Channel Number	Telemetry Name	Source	Sub-commutation Code
4:1	LO H1 Temperature (QBS1)	Rx	1
4:2	LO H2 Temperature (QBS2)	Rx	1
4:3	LO H3/4 Temperature (QBS3/4)	Rx	1
4:4	LO H5 Temperature (QBS5)	Rx	1
4:5	Mixer/LNA/Multiplexer H1 Temperature (DC1)	Rx	2
4:6	Mixer/LNA/Multiplexer H2 Temperature (DC2)	Rx	2
4:7	Mixer/LNA/Multiplexer H3/4 Temperature (DC3/4)	Rx	2
4:8	Mixer/LNA/Multiplexer H5 Temperature (DC5)	Rx	2
4:9	Quasi-optics Baseplate Temperature No.1 (Dichroic D1(A) or Polariser(B))	Rx	3
4:10	Quasi-optics Baseplate Temperature No.2 (Dichroic D2(A) or Mirror(B))	Rx	3
4:11	IF Baseplate Temperature No.1 (Top connector cavity)	Rx	3
4:12	IF Baseplate Temperature No.2 (Relay Board)	Rx	3
4:13	Scan Mech. Core Temperature	SM	4
4:14	Scan Mech. Housing Temperature	SM	4
4:15	RDM SSHM Temperature	SM	4
4:16	FDM SSHM Temperature	SM	4
4:17	Structure 1 Temperature (-A edge, next to baseplate cutout)	Baseplate	5
4:18	Structure 2 Temperature (+A edge, in between Rx and SM)	Baseplate	5
4:19	Structure 3 Temperature (-V edge, in between EE and SM)	Baseplate	5
4:20	Processor Module Temperature	EE	6
4:21	Main DC/DC Converter Module Temperature	EE	6
4:22	SCE RDM Module temp	EE	6
4:23	SCE FDM Module temp	EE	6
4:24	RF DC/DC converter Module temp	EE	5

Figure 18.5-25. Thermistor Telemetry List.

Note: Subcommutation code 7 is also used, see Figure 18.5-26.

MHS channel Number	Parameter Name	Source	Sub-commutation Code
6:1	PRT 1	OBCT	Note (1)
6:2	PRT 2	OBCT	7
6:3	PRT 3	OBCT	7
6:4	PRT 4	OBCT	7
6:5	PRT 5	OBCT	7
6:6	PRT CAL 1 (118Ω)	EE	Notes (1) & (2)
6:7	PRT CAL 2 (95.3Ω)	EE	Notes (1) & (2)
6:8	PRT CAL 3 (80.6Ω)	EE	Notes (1) & (2)

(1) Channels 6:1 and 6:6 to 6:8 appear in the SD Packet as shown in Figure 18.5-40.

(2) Channels 6:6 to 6:8 provide calibration values to allow the PRT temperature data to be accurately calibrated.

Figure 18.5-26. High Precision temperature (PRT) Telemetry

18.5.6.4.7 Current/Power Telemetry

The Current/Power Consumption Data Field is a processed subset of the internal PSE Current analogue telemetry contained in the SD Packet (See Figure 18.5-34). The field conforms to Figure 18.5-27.

<table>
<tr><td>MSB</td><td></td><td></td><td></td><td></td><td></td><td></td><td>LSB</td></tr>
<tr><td colspan="8">5V Secondary Current</td></tr>
<tr><td colspan="8">Receiver Global Secondary Power</td></tr>
<tr><td colspan="8">Total Motor Current</td></tr>
</table>

Figure 18.5-27. Current and Power Consumption Field.

The 5V Secondary Current is given by the EE + SM current, read as a single telemetry parameter.

The Receiver Global Secondary Power is given by:

Power = 8.44x (Rx +8V current) + 15x (Rx +15V current) + 15x (Rx -15V current)
where current is in amperes and power is in watts (1LSB = 0.2W)

The Total Motor Current is given by: Total = RDM Motor Current + FDM Motor Current

The result of the addition of the two 8 bit motor current telemetries shall be divided by two and truncated to reconstitute an 8 bit parameter.

18.5.6.5 CT Bus Memory Data Packet

MHS generates a Memory Data Packet (MDP) upon receipt of a 'Request Memory Data Packet' command received on the C/T Bus. The MDP is transferred to the MIU on the C/T Bus. A summary of the format is given in Figure 18.5-28.

Octet	Reference	Field Name
1 to 6	App. F	CCSDS Primary Header (Application ID, Packet Sequence Count)
7 to 12	18.5.6.4.1	CCSDS Secondary Header (Time Code)
13	(1)	Memory Packet ID/PIE ID
14,15,16	(1)	Memory Address
17 to 24	(1)	Memory Data (4 x 16 bit words)
25,26	App. F	Checksum

(1) Refer to Figure 18.5- 29 below.

Figure 18.5-28. Summary of Memory Data Packet

The MDP complies with the CCSDS standard and is 26 octets long. As indicated previously in 18.5.6.4, the Primary Header and Checksum are not transferred from the MIU to the TIP or AIP. The MDP field (excluding Time Code) is shown in Figure 18.5-29.

MSB							LSB
Memory Packet ID = 1111				PIE ID	unused (undefined)		
Start Address MS Byte							
Start Address							
Start Address LS Byte							
Data Word 1 MS Byte							
Data Word 1 LS Byte							
Data Word 2 MS Byte							
Data Word 2 LS Byte							
Data Word 3 MS Byte							
Data Word 3 LS Byte							
Data Word 4 MS Byte							
Data Word 4 LS Byte							

Figure 18.5-29. Summary of Parameters in Memory Data Packet

The Memory Packet ID is in the position of the Mode Code in HK Telemetry Packets and Test Data Packets. Mode Code = 1111 is a reserved code, so that this uniquely identifies a packet as a Memory Data Packet.

The PIE identify bit indicates which PIE is active: 0 = PIE A, 1 = PIE B.

The block start address is the 24-bit address of the returned data block. The Data Words will be sequentially read from memory in consecutive locations starting from the start address.

18.5.6.6 CT Bus Test Data Packet

MHS generates a Test Data Packet (TDP) every Scan Period (2.6667 sec) when in Self-Test Mode. This packet is transferred to the MIU on the C/T Bus in response to the 'Request HK TLM Packet' command received on the C/T Bus. A summary of the format is given in Figure 18.5-30.

Octet	Reference	Field name
1 to 6	App. F	CCSDS Primary Header (Application ID, Packet Sequence Count)
7 to 12	18.5.6.4.1	CCSDS Secondary Header (Time Code)
13	(1)	MHS Mode Code/PIE ID/Self-Test Code
14 to 28	18.5-31	Test Data
29,30	App. F	Checksum

(1) Refer to following text.

Figure 18.5-30. Summary of Test Data Packet Format

The TDP complies with the CCSDS standard and is 30 octets long. As indicated previously in 18.5.6.4, the Primary Header and Checksum are not transferred from the MIU to the TIP or AIP.

Test Data Packets are only produced in Self-test Mode and the format depends on the type of Self-test routine selected. The general format of Test Packets is as follows (excluding headers and checksum) is as shown in Figure 18.5-31.

Field Name	Length (octets)
Mode and Self-test Code	1
Test Data Field	15
Total Data Field Length	16

Figure 18.5-31. Summary of Parameters in Test Data Packet

The Mode and Self-test Code field format is as follows:

MSB							LSB
Mode Code				PIE ID	Self-Test Code		

The Mode Code is always set to 0101 for Self-test Mode and uniquely identifies the packet as a Test Packet.

The PIE ID identifies which PIE is active: 0=PIE A, 1=PIE B.

Self-test Code identifies the specific format of the Test Data Field.

(i) For Self Test Code = 0 (PIE Functions Test) the format is as follows:

Octet 1 bit 0 (MSB):	Memory Test	Done (1)/Not Done (0)
Octet 1 bit 1:	Processor Test	Done (1)/Not Done (0)
Octet 1 bit 2:	Switch TMTC Test	Done (1)/Not Done (0)
Octet 1 bit 3:	Memory Test	Pass (1)/Fail (0)
Octet 1 bit 4:	Processor Test	Pass (1)/Fail (0)
Octet 1 bit 5:	Switch TMTC Test	Pass (1)/Fail (0)
Octet 1 bits 6, 7:	unused, set to zero.	
Octets 2, 3, 4:	Memory Test: Start Address of area tested: 17 bits	
Octets 5, 6, 7:	Memory Test: End Address of area tested: 17 bits	
Octets 8, 9:	Memory Test: Number of errors: 16 bits	

If the Instrument Configuration Table (ICT) test parameters (see Appendix A) define a large block of memory to be tested, the block is divided into sub-blocks. Each sub-block is tested in a single Scan Period and the results reported in a single Test Packet. The Start and End address refer to the sub-block, and the pass/fail and error fields refer to the current sub-block only.

Octet 10 bit 0 (MSB):	Processor test: EDAC test Pass (1)/Fail (0)
Octet 10 bit 1:	Processor test: CPU test Pass (1)/Fail (0)
Octet 10 bit 2:	Processor test: Reset Source: HW_Reset (1)/Other (0)
Octet 10 bit 3:	Processor test: PCC test Pass (1)/Fail (0)
Octet 10 bit 4:	Processor test: BIC test Pass (1)/Fail (0)
Octet 10 bits 5 - 7:	unused, set to zero
Octet 11:	Switch TMTC Channels 1..8 Pass(1)/Fail(0)
Octet 12 :	Switch TMTC Channels 9..16 Pass(1)/Fail(0)
Octet 13 :	Switch TMTC Channels 17..20 Pass(1)/Fail(0); 4 LSBs unused: set to 0.
Octet 14 :	Unused. Set to zero.
Octet 15 :	Unused. Set to zero.

(ii) For Self Test Code = 1 (Fixed Pattern Test) the format is as follows:

Octets 1 - 15 : 55 hex nominally, but can be modified by changing parameter 7:3 of the ICT.

(iii) For Self Test Code = 2 (Watchdog Test) the format is as follows:

No Packets are generated in this self-test. The test is 'terminal' for the software, and causes an Instrument re-initialization.

(iv) For Self Test Code = 3 (Motor Test) the format is as follows:

If position data stored:
Octets 1, 2: Sample 1 position data (16 bits)
Octets 3, 14: Samples 2..7 position data (16 bits)
Octet 15 : Test Identification Word, see octet 1247 of Motor Self-test Extended Test Data packet.

If current demand data stored:
Octet 1 : Sample 1 current demand data (8 bits)
Octets 2 - 14 : Sample 2 - 14 current demand data (8 bits)
Octet 15 : Test Identification Word, see octet 1247 of Motor Self-test Extended Test Data packet, Section 18.5.6.9.

(v) For Self Test Code = 4 (PRT Calibration Test) the format is as follows:

Octets 1,2 : PRT 1 sample 120
Octets 3,4 : PRT 2 sample 120
Octets 5,6 : PRT 3 sample 120
Octets 7,8 : PRT 4 sample 120
Octets 9,10 : PRT 5 sample 120
Octets 11,12 : Calibration channel 1
Octets 13,14 : Calibration channel 2
Octet 15 : spare; set to zero

(vi) Self Test Code = 5: test undefined.

(vii) Self Test Code = 6: test undefined

(viii) Self Test Code = 7: test undefined

18.5.6.7 Science Data Bus Packet

MHS generates a Science Data (SD) Packet every Scan Period (2.6667 sec). The SD Packet complies with the CCSDS standard and is 1300 octets long. A summary of the format is given in Figure 18.5-32.

Octet	Reference	Field name
1 to 6	App. F (1)	CCSDS Primary Header (Application ID, Packet Sequence Count)
7 to 12	18.5.6.4.1	CCSDS Secondary Header (Time Code) (2)
13	18.5.6.4.2	MHS Mode Code/PIE ID/Sub Commutation Code (2)
14 to 17	18.5.6.4.3	Telecommand Acknowledgement Field (2)
18	18.5.6.4.4	Fault Code (2)
19 to 21	18.5.6.4.5	Switch Status Telemetry (2)
22 to 45	18.5.6.4.6	Thermistor Telemetry (2)
46 to 51	18.5.6.7.1	Current Telemetry
52	18.5.6.7.2	Science Data Status Word (3)
53 to 61	18.5.6.7.3	Signal Processing Status (3)
62 to 1141	18.5.6.7.4	Earth View Pixel Data (3)
1142 to 1189	18.5.6.7.4	Space View Pixel Data (3)
1190 to 1237	18.5.6.7.4	OBCT View Pixel Data (3)
1238 to 1253	18.5.6.7.5	PRT Data
1254 to 1298	-	Unused
1299,1300	App. F (1)	Checksum

(1) The Primary Header and Checksum are not transferred from the MIU to the AIP. Consequently a total of 1292 octets of data from each MHS scan are inserted in AIP Words 48-97 as shown previously in Figure 18.5-13. Refer to Appendix F for CCSDS Packet Format.

(2) This data in the SD Packet is available in the HK Packet as shown in Figure 18.5-14.

(3) In modes which do not generate Science Data (i.e. all modes except Scan Mode and Fixed View Mode), an 'Empty Science Data Packet' is generated, in which the remaining fields of the Science Data Packet are undefined. These octets will be set to '00'.

Figure 18.5-32. Summary of SD Packet Format

A summary of the data in an SD Packet is given in Figure 18.5-33. Full details are provided in the Reference sections.

Reference	Parameter Name
App. F	CCSDS Packet Version
	CCSDS Packet Type
	Secondary Header Flag
	Application Process
	Segment Flags
	Source Sequence Count
	Packet Length
18.5.6.4.1	Coarse Time Code
	Fine Time Code
18.5.6.4.2	Mode Code
	PIE ID
	Sub-commutation Code
	Self-Test Code
18.5.6.4.3	TC Acknowledgement: TC Clean Flag
	TC Acknowledgement: TC Conforms Flag
	TC Acknowledgement: TC Recognized Flag
	TC Acknowledgement: TC Legal Flag
	TC Acknowledgement: TC Application ID
	TC Acknowledgement: TC Packet Sequence
	TC Acknowledgement: TC Received Count
18.5.6.4.4	Fault Code: Current Monitor
	Fault Code: Thermistor Monitor
	Fault Code: Switch Fault
	Fault Code: Processor Fault
	Fault Code: DC Offset Error
	Fault Code: Scan Control Error
	Fault Code: Ref Clock Error
	Fault Code: RDM Motor Trip
	Fault Code: FDM Motor Trip
	Fault Code: PROM Switch Error
18.5.6.4.5	Switch Status Telemetry:- • TM1:1 to TM1:11 • TM2:1 to TM2:4 • TM3:4 to TM3:11
18.5.6.4.6	Thermistor Telemetry • TM4:1 to TM4:24

Refer to Reference Sections for definition of TMn:m channel numbers.

Figure 18.5-33. Summary of Telemetry parameters in a SD Packet

Reference	Parameter Name
18.5.6.7.1	+5V current (TM5:3))
	+8V current (TM5:4)
	+15V current (TM5:5)
	-15V current (TM5:6)
	RDM Motor Current (TM5:1)
	FDM Motor Current (TM5:2)
18.5.6.7.2	DC Offset Valid Flag
	Scan Control Valid Flag
	Profile Number
18.5.6.7.3	H1 DC Offset
	H2 DC Offset
	H3 DC Offset
	H4 DC Offset
	H5 DC Offset
	H1 Valid Flag
	H2 Valid Flag
	H3 Valid Flag
	H4 Valid Flag
	H5 Valid Flag
	SPE Mux Code
	H1 Gain
	H2 Gain
	H3 Gain
	H4 Gain
	H5 Gain
18.5.6.7.4	Earth Pixel 1, Mid-Pixel position
	Earth Pixel 1, H1 Data
	Earth Pixel 1, H2 Data
	Earth Pixel 1, H3 Data
	Earth Pixel 1, H4 Data
	Earth Pixel 1, H5 Data
	Earth Pixel 2 Data
	Earth Pixel 3 Data
	Earth Pixel 4 Data to Earth Pixel 90 Data

Refer to Reference Sections for definition of TMn:m channel numbers.

Figure 18.5-33. Summary of Telemetry parameters in a SD Packet (continued)

Reference	Parameter Name
18.5.6.7.4	Space View Pixel 1, Mid-Pixel position
	Space View Pixel 1, H1 Data
	Space View Pixel 1, H2 Data
	Space View Pixel 1, H3 Data
	Space View Pixel 1, H4 Data
	Space View Pixel 1, H5 Data
	Space View Pixel 2 Data
	Space View Pixel 3 Data
	Space View Pixel 4 Data
18.5.6.7.4	OBCT View Pixel 1, Mid-Pixel position
	OBCT View Pixel 1, H1 Data
	OBCT View Pixel 1, H2 Data
	OBCT View Pixel 1, H3 Data
	OBCT View Pixel 1, H4 Data
	OBCT View Pixel 1, H5 Data
	OBCT View Pixel 2 Data
	OBCT View Pixel 3 Data
	OBCT View Pixel 4 Data
18.5.6.7.5	PRT 1 Data (TM6:1)
	PRT 2 Data (TM6:2)
	PRT 3 Data (TM6:3)
	PRT 4 Data (TM6:4)
	PRT 5 Data (TM6:5)
	PRT CAL 1 (118Ω) Data (TM6:6)
	PRT CAL 2 (95.3Ω) Data (TM6:7)
	PRT CAL3 (80.6Ω) Data (TM6:8)
-	Unused
App. F	Checksum

Refer to Reference Sections for definition of TMn:m channel numbers.

Figure 18.5-33. Summary of Telemetry parameters in a SD Packet (continued)

Figure 18.5-33 notes:

(i) The Mode and Sub-Commutation field is as shown previously in Figures 18.5-17 and 18.5-18. The Sub-Commutation code is not significant for the Science Data packet as all telemetry is returned.

(ii) As with other packets, the Mode Code identifies the packet as either a Science Data Packet (Scan and Fixed View Modes), an Extended Test Packet (self-test mode), an Extended Memory Data Packet (Mode Code = '1111') or an Empty Science Data Packet (all other Modes).

(iii) The Telecommand Acknowledgement field of Science Data packets provides acknowledgement of commands received on the Science Data Bus. (Commands on the Command/telemetry Bus are acknowledged in HK Telemetry Packets.)

(iv) The Temperature Data Field of each packet will contain all twenty-four thermistor telemetry channel parameters, instead of the multiplexed four of the Housekeeping telemetry packet. The OBCT temperatures are not contained here, as all such values are allocated a separate field in the Science Data Bus

18.5.6.7.1 Science Data Packet Current Telemetry

This telemetry data provides the current consumption of various PSE power lines in the instrument. The list of analogue parameters and Telemetry References are shown if Figure 18.-34 . The field in the SD packet is as shown in Figure 18.5-35.

Channel Number	Telemetry Name	Telemetry Source
TM5:1	RDM Motor Current	EE
TM5:2	FDM Motor Current	EE
TM5:3	EE+SM +5v current	EE
TM5:4	Receiver +8V current	EE
TM5:5	Receiver +15V current	EE
TM5:6	Receiver -15V current	EE

Note: Not all of these parameters are copied into the HK Telemetry Packet. Some are combined as described in Section 18.5.6.4.7

Figure 18.5-34. Analog Current Telemetry

<table>
<tr><td>MSB</td><td></td><td></td><td></td><td></td><td></td><td></td><td>LSB</td></tr>
<tr><td colspan="8">+5V Secondary Current</td></tr>
<tr><td colspan="8">+8V Receiver Current</td></tr>
<tr><td colspan="8">+15V Receiver Current</td></tr>
<tr><td colspan="8">-15V Receiver Current</td></tr>
<tr><td colspan="8">RDM Motor Current</td></tr>
<tr><td colspan="8">FDM Motor Current</td></tr>
</table>

Figure 18.5-35. Current Telemetry Field in SD Packet

18.5.6.7.2 Science Data Status Word

The format of the Status Word is shown in Figure 18.5-36.

MSB							LSB
DC Offset Valid	Scan Control Valid	Profile		Unused			

Figure 18.5-36. Status Word Field

The 'DC Offset Valid' bit is set to a '1' when all channels calibration targets readings lie within acceptable limits, as determined by the DC Offset Algorithm. This bit will be set only in Scan Mode when the calibration targets are sampled.

The 'Scan Control Valid' bit is set to a '1' if all mid-pixel positions of the reflector during Earth, Space and OBCT views are within the limits for the Scan Mode profile, or within the limits of the requested position in Fixed View Mode. This bit will be set only in Scan Mode or Fixed View Mode.

The 'Profile' code is set to:

- 00 : Profile 0
- 01 : Profile 1
- 10 : Profile 2
- 11 : No Profile calculated (profile will be manually loaded/modified)

It is intended that Profile 0 will define the Nominal Scan Mode Profile with nominal Space View position. Profiles 1 and 2 will nominally be used for the alternate Space view positions. However, any profile can be reprogrammed to another position versus time profile by reloading the Scan Control Table profile parameters (Appendix C)

18.5.6.7.3 Signal Processing Status

The format of the Signal Processing Status field is shown in Figure 18.5-37.

<table>
<tr><td>MSB</td><td></td><td></td><td></td><td></td><td></td><td></td><td>LSB</td></tr>
<tr><td colspan="8">Channel H1 DC Offset Word</td></tr>
<tr><td colspan="8">Channel H2 DC Offset Word</td></tr>
<tr><td colspan="8">Channel H3 DC Offset Word</td></tr>
<tr><td colspan="8">Channel H4 DC Offset Word</td></tr>
<tr><td colspan="8">Channel H5 DC Offset Word</td></tr>
<tr><td>H1
VALID</td><td>H2
VALID</td><td>H3
VALID</td><td>H4
VALID</td><td>H5
VALID</td><td colspan="3">SPE MUX CODE</td></tr>
<tr><td colspan="3">H1 GAIN</td><td colspan="3">H2 GAIN</td><td colspan="2">UNUSED</td></tr>
<tr><td colspan="3">H3 GAIN</td><td colspan="3">H4 GAIN</td><td colspan="2">UNUSED</td></tr>
<tr><td colspan="3">H5 GAIN</td><td colspan="3">UNUSED</td><td colspan="2">UNUSED</td></tr>
</table>

Figure 18.5-37. Signal Processing Status Field

The 'Valid' bit is set to a '1' when all samples of this channel for this scan revolution lie within the ADC dynamic range.

H1..H5 are the 5 input channels from the Receiver. The Electronics Equipment has 6 signal processing channels, SPE1..SPE6. In the nominal configuration, the Receiver channel is connected to the corresponding EE channel e.g. H1 to SPE1, and SPE6 is unused.

The SPE Mux Code is used to identify which Receiver channel, if any, is connected to the EE redundant channel as shown below.

- SPE MUX CODE

000=H1 connected to SPE6
001=H2 connected to SPE6
010=H3 connected to SPE6
011=SPE6 not used
100=H4 connected to SPE6
101=H5 connected to SPE6
110=SPE6 not used
111=SPE6 not used

The H1...H5 Gain Fields identify the gain settings of the Receiver video output channels as in Figure 18.5-38.

Gain Code	Gain
000	0 dB
001	1 dB
010	2 dB
011	3 dB
1xx	not used

Figure 18.5-38. Receiver Gains Sub Field

18.5.6.7.4 Science Data Field

The Science Data field can be separated into Earth, Space and OBCT View Data fields, which all follow a common format. They are differentiated only by the source of the data that is written to them. The fields are arranged as shown in Figure 18.5-39.

Field name	Number of Pixel subfields
Earth	90
Space	4
OBCT	4

Figure 18.5-39. Science Data Field Format

In Fixed View Mode, the Science Data Packet is the same format as Scan Mode, but the concept of Earth, Space and OBCT pixels does not apply. All 98 pixels are for the fixed view position. The (90 + 4 + 4) pixels are however collected with the same timing as though Scan Mode were performed.

Each of the Pixel sub-fields contains a position and five pixel values. The format of a Pixel Subfield is shown in Figure 18.5-40.

MSB							LSB
Mid-pixel Position MS Byte							
Mid-pixel Position LS Byte							
Channel H1 Data MS Byte							
Channel H1 Data LS Byte							
Channel H2 Data MS Byte							
Channel H2 Data LS Byte							
Channel H3 Data MS Byte							
Channel H3 Data LS Byte							
Channel H4 Data MS Byte							
Channel H4 Data LS Byte							
Channel H5 Data MS Byte							
Channel H5 Data LS Byte							

Figure 18.5-40. Pixel Subfield Format

The 'Mid-pixel position' data is the angular position of the Reflector at the mid-point of the pixel integration period.

$$1\ \text{LSB} = \frac{7.2}{1024} = 7.03125 \times 10^{-3}\ \text{degrees}$$

18.5.6.7.5 OBCT PRT Data

The OBCT Temperature Data field contains the On-Board Calibration Target high precision temperature parameters as shown previously in Figure 18.5-26; however the data is not sub-commutated in the SD packet. Additionally, the full 12 bit range is utilized in the SD packet. The format of this block is given in Figure 18.5-41.

MSB							LSB
Unused				On-Board Target Temperature 1			
On-Board Target Temperature 1 (PRT1)							
Unused				On-Board Target Temperature 2			
On-Board Target Temperature 2 (PRT 2)							
Unused				On-Board Target Temperature 3			
On-Board Target Temperature 3 (PRT 3)							
Unused				On-Board Target Temperature 4			
On-Board Target Temperature 4 (PRT 4)							
Unused				On-Board Target Temperature 5			
On-Board Target Temperature 5 (PRT 5)							
Unused				Calibration Channel 1			
Calibration Channel 1 (PRT CAL 1: 118Ω)							
Unused				Calibration Channel 2			
Calibration Channel 2 (PRT CAL 2: 95.3Ω)							
Unused				Calibration Channel 3			
Calibration Channel 3 (PRT CAL 3: 80.6Ω)							

Figure 18.5-41. OBCT PRT Subfield Format

18.5.6.8 Extended Memory Data Packet

MHS generates an Extended Memory Data Packet (MDP) upon receipt of a 'Request Memory Data Packet' command received on the SD Bus. The EMDP is transferred to the MIU on the SD Bus. A summary of the format is given in Figure 18.5-42.

A subset of the extended memory data is available in the Memory Data Packet which is transferred on the CT Bus (refer to Section 18.5.6.5).

Octet	Reference	Field name
1 to 6	App. F	CCSDS Primary Header (Application ID, Packet Sequence Count)
7 to 12	18.5.6.4.1	CCSDS Secondary Header (Time Code)
13	(1)	Memory Packet ID/PIE ID
14,15,16	(1)	Memory Address
17 to 1040	(1)	Extended Memory Data (512 x 16 bit words)
1041,1042		Checksum

(1)Refer to Figure 18.5-42 and text below.

Figure 18.5-42. Summary of Extended Memory Data Packet Format

The EMDP complies with the CCSDS standard and is 1042 octets long. As indicated previously in 18.5.6.4, the Primary Header and Checksum are not transferred the MIU to the TIP or AIP. The EMDP field (excluding Time Code) is shown in Figure 18.5-43

Extended Memory Data Packets contain the following fields:

Octet 1:	Packet ID/PIE ID		8 bits
Octet 2:	Start Address (MS Byte)		8 bits
Octet 3:	Start Address		8 bits
Octet 4:	Start Address (LS Byte)		8 bits
Octet 5:	Data	Word 1 (MS Byte)	8 bits
Octet 6:	Data	Word 1 (LS Byte)	8 bits
Octet 7:	Data	Word 2 (MS Byte)	8 bits
Octet 8:	Data	Word 2 (LS Byte)	8 bits
		.	
		.	
		.	
Octet 1025:	Data	Word 511 (MS Byte)	8 bits
Octet 1026:	Data	Word 511 (LS Byte)	8 bits
Octet 1027:	Data	Word 512 (MS Byte)	8 bits
Octet 1028:	Data	Word 512 (LS Byte)	8 bits

MSB							LSB
Memory Packet ID = 1111				PIE ID	unused (undefined)		
Start Address MS Byte							
Start Address							
Start Address LS Byte							
Data Word 1 MS Byte							
Data Word 1 LS Byte							
Data Word 2 MS Byte							
Data Word 2 LS Byte							
. . . . .							
Data Word 511 MS Byte							
Data Word 511 LS Byte							
Data Word 512 MS Byte							
Data Word 512 LS Byte							

Figure 18.5-43. Extended Memory Data Packet Format

The Memory Packet ID is in the position of the Mode Code in Science Data Packets and Extended Test Data Packets. Mode Code = 1111 is a reserved code, so that this uniquely identifies a packet as an Extended Memory Data Packet.

The block start address is the 24-bit address of the returned data block.

The 512 Data Words will be sequentially read from memory in consecutive locations starting from the start address.

18.5.6.9 Extended Test Data Packet

MHS generates an Extended Test Data Packet (ETDP) every Scan Period (2.6667 sec) when in Self-Test Mode. This packet is transferred to the MIU on the SD Bus in response to the 'Request SD Packet' command received on the SD Bus. A summary of the format is given in Figure 18.5-44.

A subset of the extended test data is available in the Test Data Packet which is transferred on the CT Bus (refer to Section 18.5.6.6).

Octet	Reference	Field name
1 to 6	App. F	CCSDS Primary Header (Application ID, Packet Sequence Count)
7 to 12	18.5.6.4.1	CCSDS Secondary Header (Time Code)
13	(1)	MHS Mode Code/PIE ID/Self-Test Code
14 to 1298	(1)	Extended Test Data
1299,1300	App. F	Checksum

(1)Refer to Figure 18.5-44 and text below.

Figure 18.5-44. Summary of Extended Test Data Packet Format

The ETDP complies with the CCSDS standard and is 1300 octets long. As indicated previously in 18.5.6.4, the Primary Header and Checksum are not transferred the MIU to the TIP or AIP.

Extended Test Data Packets are only produced in Self-test Mode and the format depends on the type of Self-test routine selected. The general format of Extended Test Packets (excluding headers and checksum) is as shown in Figure 18.5-45.

Field Name	Length (octets)
Mode Code/PIE ID/Self-Test Code	1
Unused (set to zero)	38
Extended Test Data Field	1247

Figure 18.5-45. Extended Test Data Packet Format

The Mode Code, PIE ID and Self-test Code Field is as defined for the Test Packet (Section 18.5.6.6).

The Extended Test Data Field formats are as follows:

(i) For Self Test Code = 0 (PIE Functions Test) the format is as follows:

Octets 1..15:	PIE Functions Test Data Field (same as Test Data Packet).
Octets 16,17,18:	Memory Test: Error address 1
Octets 19,20,21:	Memory Test: Error Address 2
Octets 22..1215:	Memory Test: Error Addresses 3..400
Octets 1216..1247:	Spares, set to zero.

(ii) For Self Test Code = 1 (Fixed Pattern Test) the format is as follows:

Octets 1..1247 :	55 hex, but can be modified by changing parameter 7:3 of the ICT (Appendix A)

(iii) For Self Test Code = 2 (Watchdog Test) the format is as follows:

No Packets are generated in this self-test. The test is 'terminal' for the software, and causes an Instrument re-initialization.

(iv) For Self Test Code = 3 (Motor Test) the format is as follows:

If position data stored:

Octet 1,2 :	Sample 1 position data (16 bits) for defined period (see below)
Octets 3..1246 :	Samples 2..623 position data for defined period
Octet 1247:	Test Identification word : see below.

623 samples are collected, starting at the COUNT value defined in the ICT (see Appendix A). COUNT = 0..1151; COUNT = 0 corresponds to start of Earth Scan period.

If current demand data stored:

Octet 1 :	Sample 1 (COUNT=0) current demand data (8 bits)
Octets 2..1152 :	Sample 2..1152 (COUNT=1..1151) current demand data (8 bits)
Octets 1153..1184 :	RDM current telemetry samples 1 to 32 (8 bits).
Octets 1185..1216 :	FDM current telemetry samples 1 to 32 (8 bits).
Octets 1217..1246 :	spare, set to zero.
Octet 1247:	Test Identification word : see below.

Octet 1247 : Test Identification Word:-

1 (MSB)	2	3	4	5	6	7	8 (LSB)
data_type	data_precision	motor	Profile_type	Profile		start_block	

data_type	0 : current demand data 1 : position data
data_precision	N/A when data_type = current demand data 0 : 16 bit precision 1 : pseudo 18 bit precision
motor	0 : FDM 1 : RDM
profile_type	as defined in ICT: 0 : Profile Table 1 : Constant Velocity / Fixed View
profile	as defined by SCT 00..10 : Profiles 0,1,2 11 : Manually loaded profile
start_block	Special case start_count values: 00 : start count = 0 (i.e. samples 1..623 = start of Earth View) 01 : start count = 97 (i.e. samples 98..720 = end of Earth View) 10 : start count = 529 (i.e. samples 530..1152 = end of Earth View + transitions) 11 : start count not any of the above (defined by ICT)

(v) For Self Test Code = 4 (PRT Calibration Test) the format is as follows:

Octet 1,2	PRT 1 sample 1 (12 bits)
Octet 3,4	PRT 1 sample 2 (12 bits)
Octets 5..240	PRT 1 samples 3..120
Octets 241..480	PRT 2 samples 1..120
Octets 481..720	PRT 3 samples 1..120
Octcts 721..960	PRT 4 samples 1..120
Octets 961..1200	PRT 5 samples 1..120
Octets 1201,1202	Calibration channel 1
Octets 1203,1204	Calibration channel 2
Octets 1205,1206	Calibration channel 3
Octets 1207..1247	Spares, set to zeros.

(vi) Self Test Code = 5: test undefined.

(vii) Self Test Code = 6: test undefined

(viii) Self Test Code = 7: test undefined

18.5.7 COMMANDS

18.5.7.1 General

The MIU provides all command interfaces with the MHS. The MIU receives discrete pulse, level and serial commands that result in application of power, control levels and CCSDS format serial commands on the 1553 CT Bus to the MHS.

18.5.7.2 Discrete Commands

The discrete commands are as shown in Figure 18-46.

COMMAND	MNEMONIC	DESCRIPTION
Power On A (1) (2)	MHSNA	Relay closure in MIU applies MHS +28V Main Bus A and Pulsed Load Bus A power, PIE A selected.
Power Off A	MHSFA	Removes MHS +28 V Main Bus A and Pulsed Load Bus A power.
Power On B (1) (2)	MHSNB	Relay closure in MIU applies MHS + 28V Main Bus B and Pulsed Load Bus B power, PIE B selected.
Power Off B	MHSFB	Removes MHS +28 V Main Bus B and Pulsed Load Bus B power.
Survival Heater On	MHSHN	Relay Closure in the MIU applies +28 V Survival Heater power. Once enabled, the heaters are controlled by MHS internal thermostats.
Survival Heater Off	MHSHF	Removes +28V Survival Heater power.
Main CV Protect Enable	MHMOE	MIU applies a 0 Volt level to the MHS enabling the Main Converter Hardware Overcurrent Protection circuit.
Main CV Protect Disable	MHMOD	MIU applies a +5 Volt level to the MHS disabling the Main Converter Hardware Overcurrent Protection circuit.
RF CV Protect Enable	MHROE	MIU applies a 0 Volt level to the MHS enabling the RF Converter Hardware Overcurrent Protection circuit.
RF CV Protect Disable	MHROD	MIU applies a +5 Volt level to the MHS disabling the RF Converter Hardware Overcurrent Protection circuit.

(1) **Main Bus A and Main Bus B must never be applied at the same time.**

(2) PIE A is selected by applying Main Bus A, PIE B is selected by applying Main Bus B. One Main Bus must be switched off before switching on the other Main Bus to cause a PIE Change. If one bus is switched on with the other bus already on the PIE redundancy does not change.

Figure 18.5-46. Discrete Commands

18.5.7.3 CT Bus Serial Commands

An example of an MHS serial command as seen at the MIU input is as shown in Figure 18.5-47. The MIU assembles the serial command into a CCSDS packet for transfer to the MHS on the 1553 CT Bus. The CCSDS Command Packet fields are shown in Figure 18.5.48. The packet length is 14 words (28 octets) irrespective of the total size of the MHS commands which vary in length from 2 to 14 octets as shown in Figure 18.5-49. The MIU pads the source data field as required to complete words 7 to 13.

	Bit: 0			15	
Checksum	Checksum				
(0..7)	Command Sequence Number		Reserved		(8..15)
(0..5)	Destination ID = 00001		Length = 1 (16-bit word)		(6..15)
1	CC hex	0101	1	001	
	Mode Code	Self Test	Repeat	Fixed Pat.	

MIU Destination Code = 00000, MHS = 00001.

Figure 18.5-47. MIU Serial Command Input

Word #		Bit 0 ... Bit 15
1	Primary Header Field	Packet ID Field
2		Packet Sequence Control Field
3		Packet Length Field
4	Source Data Field	Secondary Header (1)
5		Secondary Header (1)
6		Secondary Header (1)
7		Serial Command Data (2)
8		(2)
9		(2)
10		(2)
11		(2)
12		(2)
13		(2)
14	Packet Error Control Field	Checksum

(1) Secondary Header will contain Zeros.
(2) Variable length field (1 to 7 words) depending on command type; fill words (zeros) will be added as required to fill data field.

Figure 18.5-48. CCSDS Command Packet Fields

	Command Code (hex)	Total Size (octets) (Including Cmd Code)	Number Packet Words
Set Mode	CC	2	1
Switch Command	3C	2	1
Read Telemetry	36	2	1
Set Fixed View Position	66	4	2
Fixed View Step	6C	2	1
Load Memory	33	14	7
Set Time Code	69	8	4
Load Table Data	63	10	5

Figure 18.5-49. MHS Command Field Length

NOTE

The following MHS commands can not be issued by ground command.

Command Type	Command Code (hex)	Octets
Request HK TLM Packet (1)	C3	2
Request Science Data Packet (1)	C3	2
Request Memory Data Packet (2)	39	4
Request Extended Memory Data Packet (2)	39	4

(1) The Request HK Telemetry Packet and Request Science Data packet are not required; they are issued by the MIU every scan period.
(2) The implementation of these commands requires a sequence of MIU commands since the MHS Command Code is the same for both commands. Refer to Sections 18.5.7.3.8 and 18.5.7.3.9.

The validity of commands in the different Instrument modes is given in Figure 18.5-50.

	Power -on	Warm-up	Standby	Scan	Fixed View	Self-test	Safeing	Fault
Set Mode	Y	Y	Y	Y	Y	Y	N	Y
Switch Command	Y	Y	Y	N	N	N	N	Y
Read Telemetry	Y	Y	Y	N	N	N	N	Y
Request HK TLM Packet	Y	Y	Y	Y	Y	Y	Y	Y
Set Fixed View Position	N	N	Y	N	Y	Y	N	N
Fixed View Step	N	N	N	N	Y	Y	N	N
Load Memory	Y	Y	Y	N	N	N	N	Y
Set Time Code	Y	Y	Y	N	N	N	N	N
Load Table Data	Y	Y	Y	Y	Y	Y	N	Y
Request Memory Data Packet	Y	Y	Y	N	N	N	N	Y

Figure 18.5-50. Command Validity versus Mode

The spacecraft level mnemonics for the MHS serial commands is given in Figure 18.5-51 The Reference Section of this figure provides detailed information of the required parameters for each command. Refer to Section 18.5.4 for a detailed description of the instrument operations initiated by each command.

NOTE

Figure 18.5-51 lists all MHS serial commands; however the following commands are not intended for use after launch.

a) Self Test Commands – In general the Self Test Commands will only be required for anomaly resolution. Note that HK data is not available in Self Test mode.

b) The Self Test PIE Function TMTC Test will never be exercised unless by direction in anomaly resolution.

Command	Mnemonic	Description	Reference
Set Mode Power-on	MH_STM PWR_ON	The PSE and PIE are powered and 1553 buses initialized; operational heaters are powered.	18.5.7.3.1
Set Mode Warm-up	MH_STM WRM_UP	The Receiver and Scan Mech-anism Heaters are powered.	
Set Mode Standby	MH_STM STBY	The Reflector is rotated to initialize the Zero Position Sensors and is parked at OBCT. The Receiver Operational Heaters are switched off; Scan Mechanism Power remains on.	
Set Mode Scan	MH_STM SCAN	Normal MHS operating mode; Reflector and Flywheel are rotating. Space, Earth and OBCT data in SD packet.	
Set Mode Fixed View	MH_STM F_VIEW	Default position is 0°, OBCT. Position may be altered by Fixed Position or Step commands.	
Set Mode Self–test: PIE Functions	**MH_STM S_TEST Y PIE_FUNC** (1) (2)	This command is used in con-junction with the LOAD Table Data ICT command. Setting ICT bits determine which tests are executed. Options are Memory, Processor and TC/TM self-tests.	
Set Mode Self-test: Memory	**MH_STM S_TEST Y FIX_PAT** (1) (2)	Outputs packets to 1553 buses with data field set to a fix pattern. ICT default pattern is 55 (hex).	
Set Mode Self-test: Watchdog	**MH_STM S_TEST N W_DOG** (1) (2)	The software enters a continuous loop causing a Watchdog time-out. **Ground test only.**	
Set Mode Self-test: Motor	**MH_STM S_TEST Y MOTOR** (1) (2)	This command is used in con-junction with the LOAD Table Data ICT command. Setting ICT bits determine which tests are executed. Options are RDM/FDM current demand and motor position data.	
Set Mode Self-test: PRT Calibration	**MH_STM S_TEST Y PRT** (1) (2)	The software collects PRT data at high frequency. The ADC level is stored to record the time response of the PRT measurement.	

(1) These commands are only used for anomaly resolution.

(2) The Y following S_TEST indicate Repeat bit set (Y); N indicates not set.

Figure 18.5-51. MHS Serial Commands

Command	Mnemonic	Description	Reference
Set Mode Safeing	MH-STM SAFE	Parks the Reflector at OBCT, switches off Receiver and SPE/SCE and transitions to Power-on Mode.	18.5.7.3.1
Switch Command: High Level	MH_SWC HL 37	Activates MHS internal pulsed relay commands. There are a total of 37 High Level commands as shown in Figure 18.5-56. The 37 in the string designates command number.	18.5.7.3.2
Switch Command: Steady State	MH_SWC SS 2 1	Provides levels for control of MHS internal steady state switches. The 2 in the string 2 1 designates the Channel as shown in Figure 18.5-57 and the 1 indicates Switch ON.	
Switch Command: BIM	MH_SWC BIM 11 0	Clears and sets MHS internal register bits in the Inter-module Bus. The 11 in the string 11 0 designates the Channel as shown in Figure 18.5-58 and the 0 indicates clear the register bit.	
Read Telemetry	MH_RTM 2 3 (2)	This command is intended for diagnostic purposes. It allows specific internal telemetry channels to be read and placed in memory location10D3A (hex). The 2 in the string 2 3 refers to the telemetry 'type' and the 3 species the telemetry channel.	18.5.7.3.3
Set Fixed View Position	MH_FVP 180	The command specifies the position the Reflector is to move to, in this example 180° (nadir). This command is followed by the Set Mode command MH_STM F_VIEW to effect the Reflector rotation.	18.5.7.3.4
Fixed View Position Step	MH_FVS -14.11	This command is used when in the Fixed View Mode. The Reflector will move a relative angular position from the present position defined in the command sub-field, e.g. -14.11°.	18.5.7.3.5
Load Memory	MH_LDM 013004 0000 0000 0000 0000	This command is utilized for diagnostic purposes. The sub-fields define the starting memory address (hex) and four data values(hex) that are to be written into memory.	18.5.7.3.6

(2) The telemetry channels read by this command are shown in Figures 18.5-22, 23, 24, 25, and 18.5-34; the type 6 PRT channels can not be read.

Figure 18.5-51. MHS Serial Commands (continued)

Command	Mnemonic	Description	Reference
Set Time Code	MH_STC NOW	This command sets the time of the MHS internal clock used for the Time Code Header in HK and SD packets.	18.5.7.3.7
Load Table Data	MH_LTD ICT 08 F0 00 00 0C	This command provides for changes to the ICT, TLT, SCT and DOT software tables. The sub- fields define the table Data Reference, 08 in this example, followed by four data bytes (hex) to be changed.	18.5.7.3.8
Request Memory Data Packet	MI_SULOD HK_MEM_CNT 4 MI_EULOD HK_D_ADDR 010810 MI_ACTN SET_CNTL_MD 1 (3)	An MHS Request Memory Data Packet operation requires MIU commands to replace the next HK packet data with the contents of four MHS memory locations starting with the 'start address' (hex).	18.5.7.3.9
Request Extended Memory Data packet	MI_SULOD SC_MEM_CNT 512 MI_EULOD SC_D_ADDR 010810 MI_ACTN SET_CNTL_MD 2 (3)	An MHS Request Extended Memory Data Packet operation requires MIU commands to replace the next SD packet data with the contents of 512 memory locations starting with the 'start address" (hex).	18.5.7.3.10

(3) The referenced sections provide a description of the MIU commands.

Figure 18.5-51. MHS Serial Commands (continued)

18.5.7.3.1 Set Mode

This command is used to change the mode of operation of the MHS Instrument. These Modes are defined in Section 18.5.4. The Mode Code Field in the command defines which mode is requested. Note that only legal mode transitions, as shown in Figures 18.5-5 and 18.5-50, will be accepted. Illegal mode transitions will be flagged as illegal in the Telecommand Acknowledgement Field of the HK Telemetry.

If Self-test Mode is requested, then a further subfield in the command defines which type of Self-test is to be performed, and whether the test routine is to be repeated indefinitely (until another Set Mode command) or only once, after which an automatic transition is made back to the original mode. Further sub-types and input parameters for the self-test routines are defined in the ICT.

Note that there are other ways in which the MHS Instrument can change mode as follows:

- When a fault is detected; transition to Fault Mode
- When 'automatic mode change' flag in ICT is enabled, whereupon a transition occurs either after a given time or when temperature telemetry conditions are met (see Power-on and Warm-up mode descriptions in section 18.5.4
- After 'single shot' self tests

The Set Mode command format is as shown in Figure 18.5-52.

Octet 1:	Command Code	8 bits
Octet 2:	Mode Field	4 bits
	Submode Field	4 bits
Octets 3..14:	Spares	12 x 8 bits

The spare octets will be set to zeros.

MSB							LSB
Command Code							
Mode Code				Submode code			

Figure 18.5-52. Set Mode Command Format

The Command Code is a fixed value of CC hex.

Mode Field	Code
Power-on	0000
Warm-up	0001
Standby	0010
Scan	0011
Fixed View	0100
Self-test	0101
Safeing	0110
unused	0111
unused	1000.. 1110
Reserved	1111

Figure 18.5-53 Mode Parameter Definition

The Submode Code is only used for Self-test Mode (otherwise the field has undefined contents), to identify the type of self-test routine to be performed. The Submode Code format is as follows:-

bit 4	bit 5	bit 6	bit 7
Repeat bit	Self-test code		

Repeat bit = 0: Self-Test is performed once.
One complete set of test data is generated.
Automatic return to calling mode after one Scan Period.
Repeat bit = 1: Self-Test is repeated until telecommanded to the calling mode.

Self-Test Code	Self-Test Name
0	PIE Functions
1	Fixed Pattern
2	Watchdog
3	Motor
4	PRT Calibration
5..7	Unused

Figure 18.5-54 Self Test Code Parameter Definition.

18.5.7.3.2 Switch Command

This command allows the activation of an MHS Instrument internal command channel. These are divided into 3 groups: HL commands, steady state, BIM (Inter-module bus; i.e. commands internal to the EE). These groups are listed below. The command identifies the group, channel number, and state (where applicable) of the command.

Note that all command channels are also controlled automatically by the MHS Instrument software, particularly on mode transitions.

The Switch Command format is as shown in Figure 18.5-55

Octet 1:	Command Code	8 bits
Octet 2:	Switch Channel Type/ Level/ Number	8 bits
Octets 3..14:	Spares	12 x 8 bits

The spare octets will be set to zeros.

<table>
<tr><td>MSB</td><td></td><td></td><td></td><td></td><td></td><td></td><td>LSB</td></tr>
<tr><td colspan="8">Command Code</td></tr>
<tr><td colspan="2">Type</td><td colspan="6">Switch Channel Number</td></tr>
</table>

Figure 18.5-55 Switch Command Format.

The Command Code is a fixed value of 3C hex.

The Type corresponds to the command channel number prefix (see figures 18.5-56 to 18.5-58) as follows:-

Type = 00	not used
Type = 01	High Level commands (e.g. pulsed relay commands) Commands 1:n (see figure 6.1-1) where n is the Switch Channel Number (max capability of 64).

For Type = 10 and 11 the command format is:-

<table>
<tr><td>MSB</td><td></td><td></td><td></td><td></td><td></td><td></td><td>LSB</td></tr>
<tr><td colspan="8">Command Code</td></tr>
<tr><td colspan="2">Type</td><td>Level</td><td colspan="5">Switch Channel Number</td></tr>
</table>

Type = 10	'Steady state' commands (e.g. FET control) Commands 2:n (see figure 6.2-1) Level = 0 = Switch OFF; Level = 1 = Switch ON
Type = 11	'BIM register' commands (for SCE, SPE functions) Commands 3 : n (see figure 6.3-1) Level = 0 = clear register bit Level = 1 = set register bit

Figure 18.5-56 lists the High Level Command channels (typically used for the control of latching relays).

Figure 15.5-57 lists the steady state commands for the control of steady state switches (typically power FETs).

Figure 18.5-58 lists the switch commands which are implemented within the EE using the Inter-Module Bus (BIM).

MHS Channel #	Command Name	Destination
1:1	H1 ON	Rx
1:2	H1 OFF	Rx
1:3	H1 Select LO A	Rx
1:4	H1 Select LO B	Rx
1:5	H2 ON	Rx
1:6	H2 OFF	Rx
1:7	H2 Select LO A	Rx
1:8	H2 Select LO B	Rx
1:9	H3/4 Frontend ON	Rx
1:10	H3/4 Frontend OFF	Rx
1:11	H3/4 Select LO A	Rx
1:12	H3/4 Select LO B	Rx
1:13	H3 Backend ON	Rx
1:14	H3 Backend OFF	Rx
1:15	H4 Backend ON	Rx
1:16	H4 Backend OFF	Rx
1:17	H5 ON	Rx
1:18	H5 OFF	Rx
1:19	H5 Select LO A	Rx
1:20	H5 Select LO B	Rx
1:21	RFCV ON	EE
1:22	RFCV OFF	EE
1:23	H1 Gain Reset	Rx
1:24	H1 Gain 1dB	Rx
1:25	H1 Gain 2dB	Rx
1:26	H2 Gain Reset	Rx
1:27	H2 Gain 1dB	Rx
1:28	H2 Gain 2dB	Rx
1:29	H3 Gain Reset	Rx
1:30	H3 Gain 1dB	Rx
1:31	H3 Gain 2dB	Rx
1:32	H4 Gain Reset	Rx
1:33	H4 Gain 1dB	Rx
1:34	H4 Gain 2dB	Rx
1:35	H5 Gain Reset	Rx
1:36	H5 Gain 1dB	Rx
1:37	H5 Gain 2dB	Rx

Figure 18.5-56 High Level Command List.

MHS Channel #	Command Name	Command Levels	Destination
2:1	Receiver Operational Heaters ON/OFF	0=Off	EE
2:2	SM Operational Heaters ON/OFF	0=Off	EE
2:3	Aux Operational Heaters ON/OFF	0=Off	EE
2:4	SPE/SCE ON/OFF	0=Off	EE

Figure 18.5-57 Steady State Command List.

MHS Channel Number	Command Name	Command Level
3:1	SPE Mux Code	MSB
3:2	SPE Mux Code	
3:3	SPE Mux Code	LSB
3:4	Select RDM Zero Position Sensors A/B	0=A
3:5	Select FDM Zero Position Sensors A/B	0=A
3:6	Select RDM Motor Sensors A/B	0=A
3:7	Select FDM Motor Sensors A/B	0=A
3:8	RDM Motor Supply ON/OFF	0=Off
3:9	FDM Motor Supply ON/OFF	0=Off
3:10	RDM Motor Current Trip enable/disable	0=enabled
3:11	FDM Motor Current Trip enable/disable	0=enabled

Figure 18.5-58 BIM Register Command List.

The coding of 3:1 to 3:3 SPE Mux Code bits is the same as that given in Section 18.5.6.7.3

18.5.7.3.3 Read Telemetry

This command is intended for diagnostic purposes. It allows a specific MHS internal telemetry channel to be read. The telemetry channels are divided into 6 groups: switch status, bi-level status, BIM status (Inter-module bus; i.e. internal to the EE), temperature, current, high precision temperature. The command identifies the group and channel number of the telemetry.

Upon receiving this command, the MHS Instrument reads the telemetry and places it in a known location of processor memory. A 'Request Memory Data Packet' is then required to collect the data over the 1553 interface.

Note that the MHS Instrument generates HK Telemetry Packets at 8/3 second intervals which contain telemetry data. The data in this packet is sub-commutated over 7 packets, so all channels are received in a 7x8/3=18.67 second period. The 'Read Telemetry' command can be used if a particular channel is required sooner than this. Note also that full HK telemetry (i.e. all telemetry channels) are included in every Science Data Packet (i.e. 8/3 seconds intervals) which is collected on the SD Bus.

The Switch Command format is as shown in Figure 18.5-59.

Octet 1:	Command Code	8 bits
Octet 2:	Telemetry Channel Number	5 bits
	Telemetry Channel Type	3 bits
Octets 3..14:	Spares	12 x 8 bits

The spare octets will be set to zeros.

<table>
<tr><td>MSB</td><td></td><td></td><td></td><td></td><td></td><td></td><td>LSB</td></tr>
<tr><td colspan="8">Command Code</td></tr>
<tr><td colspan="3">Type</td><td colspan="5">Telemetry Channel Number</td></tr>
</table>

Figure 18.5-59 Switch Command Format.

The Command Code is a fixed value of 36 hex.

The Type corresponds to the Telemetry Channel Number prefix (see Figures 18.5-22, 23, 24, 25 and 18.5-34). The Telemetry Channel Number corresponds to those listed in the afore mentioned tables.

Note: The Read Telemetry command is not available for Type = 6 (i.e. PRT data, channels 6:1 to 6:8).

18.5.7.3.4 Set Fixed View Position

This command is specific to the Fixed View Mode operation. When this command is received in Fixed View Mode (or Self-test [Fixed View Mode]) the Reflector is moved to the position defined by the command. There is no limit to the number of times the position can be changed. If this command is sent in Standby Mode, the position is stored and the Reflector will move to this position when Fixed View Mode is next selected.

The Set Fixed View command format is as shown in Figure 18.5-60.

Octet 1:	Command Code	8 bits
Octet 2:	Unused	8 bits
Octet 3:	Pointing Position MS Byte	8 bits
Octet 4:	Pointing Position LS Byte	8 bits
Octets 5..14:	Spares	10 x 8 bits

The spare octets will be set to zeros.

MSB							LSB
Command Code							
Unused							
Pointing Angle MS Byte							
Pointing Angle LS Byte							

Figure 18.5-60. Set Fixed View Position Command Format.

The Command Code is a fixed value of 66 hex.

The pointing angle is an absolute position, measured in degrees where 1 LSB = 0.01 degrees. Angles greater than 359.99° are interpreted as modulo 360.

18.5.7.3.5 Fixed View Position Step

This command is specific to Fixed View Mode operation. When this command is received in Fixed View Mode (or Self-test[Fixed View Mode]) the Reflector is moved by a relative amount as defined by the command. The step size is in multiples of 1/10th of a pixel field of view (10/9°) and can be forwards or backwards. The maximum step size is 14.11°. There is no limit to the number of times the position can be changed.

The Fixed View Position Step command format is as shown in Figure 18.5-61.

Octet 1:	Command Code	8 bits
Octet 2:	Step Direction	1 bit
	Step Size	7 bits
Octets 3..14:	Spares	12 x 8 bits

The spare octets will be set to zeros.

MSB							LSB
Command Code							
Step Dir.	Step Size						

Figure 18.5-61 Fixed View Step Command Format.

The Command Code is a fixed value of 6C hex.

Step Direction=0 : indicates forwards (i.e. direction of rotation for nominal Scan Mode Profile).
Step Direction=1 : indicates backwards

The Step Size is a relative step, measured in degrees, from the current pointing position.

Step Size 1LSB = 1/9 degrees (i.e. 1/10th of a pixel).

18.5.7.3.6 Load Memory

This command is provided for diagnostic operations. It allows any area of the processor memory to be changed. The command defines the start address of a block of 4 16-bit words, plus the four data values which are to be written into memory. This allows code and data areas of the software to be changed during flight.

The Load Memory command format is as shown in Figure 18.5-62.

Octet 1:	Command Code			8 bits
Octet 2:	Start Address (MS Byte)			8 bits
Octet 3:	Start Address			8 bits
Octet 4:	Start Address (LS Byte)			8 bits
Octet 5:	Data	Word 1	(MS Byte)	8 bits
Octet 6:	Data	Word 1	(LS Byte)	8 bits
Octet 7:	Data	Word 2	(MS Byte)	8 bits
Octet 8:	Data	Word 2	(LS Byte)	8 bits
Octet 9:	Data	Word 3	(MS Byte)	8 bits
Octet 10:	Data	Word 3	(LS Byte)	8 bits
Octet 11:	Data	Word 4	(MS Byte)	8 bits
Octet 12:	Data	Word 4	(LS Byte)	8 bits
Octet 13:	Checksum		(MS Byte)	8 bits
Octet 14:	Checksum		(LS Byte)	8 bits

MSB							LSB
Command Code							
Start Address MS Byte							
Start Address							
Start Address LS Byte							
Data Word 1 MS Byte							
Data Word 1 LS Byte							
Data Word 2 MS Byte							
Data Word 2 LS Byte							
Data Word 3 MS Byte							
Data Word 3 LS Byte							
Data Word 4 MS Byte							
Data Word 4 LS Byte							
Checksum MS Byte							
Checksum LS Byte							

Figure 18.5-62 Load Memory Command Format.

The Command Code is a fixed value of 33 hex.

The block start address is a 24-bit address passed in as parameter.

The Data Words will be written to memory in consecutive locations.

The Checksum will be the exclusive-OR of all the other octet pairs (i.e. Command/unused octet pair to Data Word 4 octet pair).

18.5.7.3.6 Set Time Code

This command defines a new value of the MHS Instrument on-board time which is used for datation of all data generated by the MHS Instrument (HK telemetry, science data, test data, memory data). The clock is set to the value defined by the command on the next occurrence of the 8SP signal. At MHS Instrument switch-on, the clock is set to zero.

The implied epoch is midnight, January 1, 1958. This time will be extracted from the on-board clock maintained by the MINOS. It will be the responsibility of the ground control to upload an absolute time. In general this will be a time value that will become valid at the next occurrence of the 8SP clock.

The Set Time Code command format is as shown in Figure 18.5-63.

Octet 1:	Command Code	8 bits
Octet 2:	Unused (undefined)	8 bits
Octet 3:	Coarse Time (MS Byte)	8 bits
Octet 4:	Coarse Time	8 bits
Octet 5:	Coarse Time	8 bits
Octet 6:	Coarse Time (LS Byte)	8 bits
Octet 7:	Fine Time (MS Byte)	8 bits
Octet 8:	Fine Time (LS Byte)	8 bits
Octets 9..14:	Spares	6 x 8 bits

The spare octets will be set to zeros.

MSB							LSB
Command Code							
Unused (undefined)							
Coarse Time (MS Byte)							
Coarse Time							
Coarse Time							
Coarse Time (LS Byte)							
Fine Time (MS Byte)							
Fine Time (LS Byte)							

Figure 18.5-63. Set Time Code Command Format.

The Command Code is a fixed value of 69 hex.

Octets 3 .. 6 : Coarse Time 32 bits (LSB=1 second)
Octets 5,6 : Fine Time 16 bits (LSB=2^{-16} seconds)

Instrument time is set to the defined value at the next 8SP event.

18.5.7.3.7 Load Table Data

This command is used to change the contents of the software tables to a value different to the default values stored in PROM. At MHS Instrument switch-on, all tables are initialized to the PROM values.

See Section 18.5.4.6 and 18.5.7.4.1 for a desciption of the usage of these tables, and Appendices A, B, C and D for the format of the tables.

The command gives the table reference number (0..3), the data reference number, and the actual data (4 octets). One data reference consists of 4 octets, which can represent a single floating point number, or different combinations of 16 and 8 bit numbers, and octets with bitwise significance.

The Load Table Data command format is as shown in Figure 18.5-64.

Octet 1:	Command Code	8 bits
Octet 2:	Unused (undefined)	4 bits
	Table Reference	4 bits
Octet 3:	Unused (undefined)	4 bits
	Data Reference (MS Nibble)	4 bits
Octet 4:	Data Reference (LS Byte)	8 bits
Octet 5:	Data Byte 1	8 bits
Octet 6:	Data Byte 2	8 bits
Octet 7:	Data Byte 3	8 bits
Octet 8:	Data Byte 4	8 bits
Octet 9:	Checksum (MS Byte)	8 bits
Octet 10:	Checksum (LS Byte)	8 bits
Octets 11..14:	Spares	4 x 8 bits

The spare octets will be set to zeros.

MSB							LSB
Command Code							
Unused (undefined)				Table Reference			
Unused (undefined)				Data Reference			
Data Reference							
Data Word 1							
Data Word 2							
Data Word 3							
Data Word 4							
Checksum MS Byte							
Checksum LS Byte							

Figure 18.5-64. Load Table Data Command Format.

The Command Code is a fixed value of 63 hex.

The Table Reference is a code which points to one of the internally implemented databases:

Code	Database Table
0000	Instrument Configuration Table
0001	Telemetry Limits Table
0010	Scan Control Table
0011	DC Offsets Table
0100 .. 1111	Unused

The Data Reference is a pointer value from 0 .. 4095. It is used to select the required entry in the table.

The data tables implemented are described in appendices A, B, C & D.

The Checksum will be the exclusive-OR of all other octet pairs (i.e. Command Code/Table Ref octet pair to Data Word 3/4 octet pair).

18.5.7.3.8 Request Memory Data Packet

The implementation of the MHS Request Memory Data Packet command is as described below. The implementation of this command as a sequence is required because of the use, by MHS, of the same 'op code' (39Hex) for either the 'Request Memory Data Packet' or 'Request Extended Memory Data Packet' commands. To implement the MHS 'op code' selection, the MIU is explicitly told to send a packet to either the 'Science' or 'C&T' RT.

The required MIU commands are as follows.

MI_SULOD HK_MEM_CNT 4	This is a MIU Type 3 Single Integer Load command. The MIU Opcode is 3001 (hex), Housekeeping Bus Memory Dump Word Count.
MI_EULOD HK_D_ADDR 0104E4	This is a MIU Type 4 Extended Unsigned Integer Load command. The MIU Opcode is 4004 (hex), Housekeeping Bus Dump Start Address. The 0104E4 (hex) represents a start address.
MI_ACTN SET_CNTL_MD 1	This is a MIU Type 9 Action command. The MIU Opcode is 9009 (hex), Set Bus Controller Mode. The mode argument 1 specifies a HK Dump.

18.5.7.3.9 Request Extended Memory Data Packet

The implementation of the MHS Request Extended Memory Data Packet command is as described below. The implementation of this command as a sequence is required because of the use, by MHS, of the same 'op code'(39Hex) for either the 'Request Memory Data Packet' or 'Request Extended Memory Data Packet' commands. To implement the MHS 'op code' selection, the MIU is explicitly told to send a packet to either the 'Science' or 'C&T' RT.

The required MIU commands are as follows.

MI_SULOD SC_MEM_CNT 512	This is a MIU Type 3 Single Integer Load command. The MIU Opcode is 3002 (hex), Science Bus Memory Dump Word Count.
MI_EULOD SC_D_ADDR 0104E4	This is a MIU Type 4 Extended Unsigned Integer Load command. The MIU Opcode is 4005 (hex), Science Bus Dump Start Address. The 0104E4 (hex) represents a start address.
MI_ACTN SET_CNTL_MD 2	This is a MIU Type 9 Action command. The MIU Opcode is 9009 (hex), Set Bus Controller Mode. The mode argument 2 specifies a Science Dump.

18.5.7.4 Command Sequences

Command Sequences for the MHS are provided in the following Sections. The prerequisite for the listed sequences is MIU On in Normal Telemetry Mode.

18.5.7.4.1 In-orbit Initialization

The following command sequences list the commands required to initialize the MHS from OFF Mode to the normal operational SCAN Mode. Implicit in this sequence are delays (hours or orbital revolutions) necessary for the instrument components to achieve the operating temperatures required prior to transition to the subsequent mode.

Note

The automatic transition mode is not used; all mode transitions are effected by mode commands. ICT Data Reference 0, Mode Change Control, is set to the default value 00 (hex), manual (commanded) transition.

(1) Verify Electronics Equipment Temperature (16AN 16) is -25° C or greater.

(2) Main CV Protect Enable	MHMOE
(3) RF CV Protect Enable	MHROE
(4) Main Power B Off	MHSFB
(5) Main Power A On	MHSNA
(6) Survival Heater Off	MHSHF
(7) Set MHS mode to Power-on	MH_STM PWR_ON

(8) Verify RDM and SDM Scan Sensor Head Module (SSHM) temperatures are -40° C or greater.

(9) Turn SPE/SCE On MH_SWC SS 4 1

(10) Load Table Data, PFM or FM2 (See Appendix E).

PFM	FM2
MH_LTD SCT 11 7D 6B 85 06	MH_LTD DOT 00 3F 55 56 4C
MH_LTD SCT 84 79 5A E1 08	MH_LTD DOT 01 38 82 73 2C
MH_LTD SCT 00 F4 F6 00 00	MH_LTD DOT 03 E6 58 7F F8
MH_LTD SCT 07 62 00 00 08	MH_LTD SCT 11 4D 37 6D 08
MH_LTD SCT 30 62 00 00 08	MH_LTD SCT 84 53 9B B6 09
MH_LTD TLT 87 2D 29 00 00	MH_LTD SCT 01 0F 3C 3C 00
MH_LTD TLT 88 5D 3C 00 00	MH_LTD SCT 12 41 89 38 FA
MH_LTD TLT 90 2D 29 00 00	MH_LTD SCT 13 60 00 00 05
MH_LTD TLT 91 5D 3C 00 00	MH_LTD SCT 14 50 00 00 09
MH_LTD TLT 92 47 41 1E 17	MH_LTD SCT 90 5A 1C AC FA
MH_LTD DOT 00 3F 5E 46 27	MH_LTD SCT 91 60 00 00 04
MH_LTD DOT 01 57 82 73 2C	MH_LTD SCT 92 78 00 00 08
MH_LTD SCT 01 0F 3C 3C 00	MH_LTD SCT 00 EE F6 80 00
MH_LTD DOT 03 E6 58 7F F8	MH_LTD SCT 07 5F 00 00 08
MH_LTD ICT 01 99 9A AA 49	MH_LTD SCT 30 62 00 00 08
	MH_LTD TLT 87 2D 29 00 00
	MH_LTD TLT 88 5D 3C 00 00
	MH_LTD TLT 90 2D 29 00 00
	MH_LTD TLT 91 5D 3C 00 00
	MH_LTD TLT 92 47 41 1E 17
	MH_LTD ICT 01 99 9A 9A 49

(11) Dump MHS Table Data via Extended Test Data Packets as follows:

MIU_SULOD SC-MEM_CNT 512
MI_EULOD SC-ADDR 0104E4 (TLT)
MI_ACTN SET_CNTL MD 2

MIU_SULOD SC-MEM_CNT 512
MI_EULOD SC-ADDR 0107E1 (DOT and part of SCT)
MI_ACTN SET_CNTL MD 2

MIU_SULOD SC-MEM_CNT 512
MI_EULOD SC-ADDR 014F84 (ICT and part of SCT)
MI_ACTN SET_CNTL MD 2

MIU_SULOD SC-MEM_CNT 512
MI_EULOD SC-ADDR 013003 (1 parameter only: SCT 3:1)
MI_ACTN SET_CNTL MD 2

(12) Verify memory modified with data from Table Load commands. Memory locations for each Table Reference are defined in Appendices A, B, C and D.

(13) Verify the receiver temperatures, 4.1 through 4.12 of Figure 18.5-25, are -25° C or greater.

(14) Set MHS mode to Warm-up MH_STM WRM_UP

(15) Refer to Figure 18.5-25 for telemetry channels and verify the following temperatures:
Receiver temperatures 4.1 to 4.12 are **+10°** C or greater **(TBC)**
Scan Mechanism temperatures 4.13 to 4.16 are **0°** C or greater **(TBC)**
Baseplate temperatures 4.17 to 4.19 are **-30°** C or greater **(TBC)**
Electronics Equipment temperature 4.20 to 4.24 are **0°** C or greater **(TBC)**

(16) Set MHS mode to Standby MH_STM STBY

(17) Set MHS mode to Scan MH_STM Scan

18.5.7.4.2 Standby to Fixed View/Fixed View Step

(1) Verify MHS Mode is Standby; if not issue Standby command:
Set MHS mode to Standby MH_STM STBY

(2) Set Fixed View Position MH_FVP (POS)
where POS is in the range of 0 to 359.9°

(3) Set MHS mode to Fixed View MH_STM F_VIEW

(4) If desired Fixed View may be stepped in increments of ±0.11°, maximum step size is ±14.11° from present position:
Set Fixed View Step MH_FVS (POS)

(5) At completion of Fixed View return to Standby:
Set MHS mode to Standby MH_STM STBY

18.5.7.4.3 Scan Mode to Off Mode (Normal Turn Off

(1) Set MHS Mode to Standby MH_STM STBY

(2) Set MHS mode to Power-on MH_STM PWR_ON

(3) Power Off A MHSFA

(4) Power Off B MHSFB

(5) Survival Heater On MHSHN

18.5.7.4.4 <u>Any Mode to Safe Mode (Emergency Off)</u>

(1) Set MHS to Safe Mode MH_STM SAFE

(2) Wait 8 seconds (MHS now in Power-on Mode).

(3) Power Off A	MHSFA
(4) Power Off B	MHSFB
(5) Survival Heater On	MHSHN

18.5.7.4.5 <u>Fault Mode Sequence</u>

(1) In the event the MHS Mode Code telemetry indicates Fault Mode check for a Current Monitor or Thermistor Monitor Fault Code. If either is set **and sufficient contact time remains,** dump the Telemetry Limits Table:

MIU_SULOD SC-MEM_CNT 512
MI_EULOD SC-ADDR 0104E4 (TLT)
MI_ACTN SET_CNTL MD 2

(2) Perform Any Mode to Safe Mode, 18.5.7.4.4

This space intentionally blank.

18.5.8 MIRP PROCESSING

MIRP processing is not applicable to the MHS.

18.5.9 POWER INPUT AND PROFILE

18.5.9.1 Power Sources

The MHS Main Power A and B Busses are supplied by the spacecraft +28 Volt Main Bus.

The MHS Pulsed Load Bus A and B Buses and Survival Heater Power are supplied by the spacecraft + 28 Volt Pulsed Load Bus.

18.5.9.2 Power Requirements

The power requirements are as shown in Figure 18.5-65.

	Nominal Power (Watts)			Worst Case Power (Watts)		
Mode	Main Bus	Pulsed Load Bus	Survival Bus	Main Bus	Pulsed Load Bus	Survival Bus
Off	0.0	0.0	60	0.0	0.0	66
Power-on	29.0	27.0	0	39.0	33.0	0
Warm-up	58.0	6.5	0	76.0	8.0	0
Standby	58.0	9.0	0	76.0	12.0	0
Scan	58.0	2.5	0	76.0	4.0	0
Fixed View	58.0	9.0	0	76.0	12.0	0

Figure 18.5-65. Power Consumption versus Mode of Operation

18.5.10 ACTIVATION AND EVALUATION PROCEDURES AND TIMELINE

The activation of the MHS is specified in 18.5.7.4.1. There is no requirement for a pre-activation outgas period therefore there is no defined waiting period before activation begins. The activation timeline is primarily driven by the temperature constraints for transition from each mode as specified in 18.5.7.4.1.

18.5.11 CALIBRATION REQUIREMENTS

There are no specific on-orbit calibration procedures for the MHS. However changes to receiver gain and DAC offsets over the life of the instrument may be required (refer to 18.5.4.3). Switch commands defined in 18.5.7.3.2 are used to select the required receiver gain. The DAC offsets may be automatically corrected by a Table Load command to ICT0:3 (see Appendix A).

18.5.12 ROUTINE COMMAND REQUIREMENTS

There are no specific routine command requirements during normal MHS operation. When necessary the Fixed View, Fixed View Step (see 18.5.4.7.2) and change of the Scan Profile with a Table Load command to SCT 3:1 (see Appendix C) can be commanded.

18.5.13 EVALUATION OF NOMINAL PERFORMANCE AND TREND REQUIREMENTS

18.5.13.1 Pre-activation and Post-activation Monitoring

Pre-activation monitoring of the MHS following launch is limited to monitoring of the analog survival temperatures of Figure18.5-10. Subsequent to activation, Power-on Mode, the fault code field detailed in 18.5.6.4.4 and the instrument currents and temperatures of Figures 18.5-66 and 18.5-67 are monitored to assess general instrument status and health.

18.5.13.2 Functional Evaluation

Selective scan position identification and the radiometric data associated with the applicable positions are employed to evaluate functional performance of the MHS when the instrument is operational. The raw radiometric counts for space and blackbody are evaluated for each of the five radiometric channels. The shaft positions confirmed are:

(a) Space calibration pixels 1 to 4

(b) Blackbody calibration view pixels 1 to 4

(c) Earth View pixel 1

(d) Earth view pixel 45

18.5.13.3 Trending

Long term performance assessment involves trending of the current and temperature data as shown in Figures 18.5-66 and 18.5-67 and the scan position and radiometric data described in 18.5.13.2 above.

CHANNEL NUNBER	PARAMETER		LIMITS RED LO	YELLOW LO	YELLOW HI	RED HI
5:1	RDM Motor Current	(ma)	0	0	110	165
5:2	FDM Motor Current	(ma)	0	0	110	165
5:3	EE+SM +5V Current (1)	(ma)	504	572	706	773
5:3	EE+SM +5V Current (2)	(ma(	622	706	1093	1194
5:4	Receiver +8V Current	(ma)	0	0	352	595
5:5	Receiver +15V Current	(ma)	0	0	161	258
5:6	Receiver -15V Current	(ma)	0	0	49	70

(1) SPE/SCE Off
(2) SPE/SCE On

Figure 18.5-66A. Analog Telemetry Limits, Power-on

CHANNEL NUNBER	PARAMETER		LIMITS RED LO	YELLOW LO	YELLOW HI	RED HI
5:1	RDM Motor Current (1)	(ma)	0	0	110	165
5:1	RDM Motor Current (2)	(ma)	0	0	96	152
5:2	FDM Motor Current (1)	(ma)	0	0	110	165
5:2	FDM Motor Current (2)	(ma)	0	0	96	152
5:3	EE+SM +5V Current	(ma)	622	706	1093	1194
5:4	Receiver +8V Current	(ma)	0	1058	1830	1874
5:5	Receiver +15V Current	(ma)	0	734	927	992
5:6	Receiver -15V Current	(ma)	0	143	194	239

(1) Warm-up
(2) Standby

Figure 18.5-66B. Analog Telemetry Limits, Warm-up and Standby

CHANNEL NUNBER	PARAMETER		LIMITS RED LO	YELLOW LO	YELLOW HI	RED HI
5:1	RDM Motor Current	(ma)	530	565	771	799
5:2	FDM Motor Current	(ma)	530	565	771	799
5:3	EE+SM +5V Current	(ma)	622	706	1093	1194
5:4	Receiver +8V Current	(ma)	0	1058	1830	1874
5:5	Receiver +15V Current	(ma)	0	734	927	992
5:6	Receiver -15V Current	(ma)	0	143	194	239

Figure 18.5-66C. Analog Telemetry Limits, Scan, Fixed View

			LIMITS	°C	
CHANNEL NUNBER	PARAMETER	RED LO	YELLOW LO	YELLOW HI	RED HI
4:1	LO H1 Temperature (QBS1)	+60	+55	-33.4	-33.5
4:2	LO H2 Temperature (QBS2)	+60	+55	-33.4	-33.5
4:3	LO H3/4 Temperature (QBS3/41)	+60	+55	-33.4	-33.5
4:4	LO H5 Temperature (QBS5)	+60	+55	-33.4	-33.5
4:5	Mixer/LNA/MUX H1 Temp. (DC1)	+60	+55	-33.4	-33.5
4:6	Mixer/LNA/MUX H2 Temp. (DC2)	+60	+55	-33.4	-33.5
4:7	Mixer/LNA/MUX H3/4 Temp. (DC3/4)	+60	+55	-33.4	-33.5
4:8	Mixer/LNA/MUX H5 Temp. (DC5)	+60	+55	-33.4	-33.5
4:9	Quasi-optics Baseplate Temp. #1	+60	+55	-33.4	-33.5
4:10	Quasi-optics Baseplate Temp. #2	+60	+55	-33.4	-33.5
4:11	IF Baseplate Temperature #1	+60	+55	-33.4	-33.5
4:12	IF Baseplate Temperature #2	+60	+55	-33.4	-33.5
4:13	Scan Mech. Core Temperature	+50	+45	-33.4	-33.5
4:14	Scan Mech. Housing Temperature	+50	+45	-33.4	-33.5
4:15	RDM SSHM Temperature	+50	+45	-33.4	-33.5
4:16	FDM SSHM Temperature	+50	+45	-33.4	-33.5
4:17	Structure 1 Temperature	+60	+55	-33.4	-33.5
4:18	Structure 2 Temperature	+60	+55	-33.4	-33.5
4:19	Structure 3 Temperature	+60	+55	-33.4	-33.5
4:20	Processor Module Temperature	+75	+65	-20	-25
4:21	Main DC/DC Converter Module Temp.	+77	+67	-20	-25
4:22	SCE RDM Module Temperature	+76	+66	-20	-25
4:23	SCE FDM Module Temperature	+76	+66	-20	-25
4:24	RF DC/DC Converter Module Temp.	+67	+57	-20	-25

Figure 18.5-67A. Temperature Limits, Power-on

		LIMITS °C			
CHANNEL NUNBER	PARAMETER	RED LO	YELLOW LO	YELLOW HI	RED HI
4:1	LO H1 Temperature (QBS1)	+50	+45	-20	-25
4:2	LO H2 Temperature (QBS2)	+50	+45	-20	-25
4:3	LO H3/4 Temperature (QBS3/41)	+50	+45	-20	-25
4:4	LO H5 Temperature (QBS5)	+50	+45	-20	-25
4:5	Mixer/LNA/MUX H1 Temp. (DC1)	+50	+45	-20	-25
4:6	Mixer/LNA/MUX H2 Temp. (DC2)	+50	+45	-20	-25
4:7	Mixer/LNA/MUX H3/4 Temp. (DC3/4)	+50	+45	-20	-25
4:8	Mixer/LNA/MUX H5 Temp. (DC5)	+50	+45	-20	-25
4:9	Quasi-optics Baseplate Temp. #1	+50	+45	-20	-25
4:10	Quasi-optics Baseplate Temp. #2	+50	+45	-20	-25
4:11	IF Baseplate Temperature #1	+50	+45	-20	-25
4:12	IF Baseplate Temperature #2	+50	+45	-20	-25
4:13	Scan Mech. Core Temperature	+50	+45	-35	-40
4:14	Scan Mech. Housing Temperature	+50	+45	-35	-40
4:15	RDM SSHM Temperature	+50	+45	-35	-40
4:16	FDM SSHM Temperature	+50	+45	-35	-40
4:17	Structure 1 Temperature	+60	+55	-35	-40

		LIMITS °C			
CHANNEL NUNBER	PARAMETER	RED LO	YELLOW LO	YELLOW HI	RED HI
4:18	Structure 2 Temperature	+60	+55	-35	-40
4:19	Structure 3 Temperature	+60	+55	-35	-40
4:20	Processor Module Temperature	+75	+65	-20	-25
4:21	Main DC/DC Converter Module Temp.	+77	+67	-20	-25
4:22	SCE RDM Module Temperature	+76	+66	-20	-25
4:23	SCE FDM Module Temperature	+76	+66	-20	-25
4:24	RF DC/DC Converter Module Temp.	+67	+57	-20	-25

Figure 18.5-67B. Temperature Limits, Warm-up

		LIMITS °C			
CHANNEL NUNBER	PARAMETER	RED LO	YELLOW LO	YELLOW HI	RED HI
4:1	LO H1 Temperature (QBS1)	+40	+35	+15	+10
4:2	LO H2 Temperature (QBS2)	+40	+35	+15	+10
4:3	LO H3/4 Temperature (QBS3/41)	+40	+35	+15	+10
4:4	LO H5 Temperature (QBS5)	+40	+35	+15	+10
4:5	Mixer/LNA/MUX H1 Temp. (DC1)	+40	+35	+15	+10
4:6	Mixer/LNA/MUX H2 Temp. (DC2)	+40	+35	+15	+10
4:7	Mixer/LNA/MUX H3/4 Temp. (DC3/4)	+40	+35	+15	+10
4:8	Mixer/LNA/MUX H5 Temp. (DC5)	+40	+35	+15	+10
4:9	Quasi-optics Baseplate Temp. #1	+40	+35	+15	+10
4:10	Quasi-optics Baseplate Temp. #2	+40	+35	+15	+10
4:11	IF Baseplate Temperature #1	+40	+35	+15	+10
4:12	IF Baseplate Temperature #2	+40	+35	+15	+10
4:13	Scan Mech. Core Temperature	+50	+45	-5	-10
4:14	Scan Mech. Housing Temperature	+50	+45	-5	-10
4:15	RDM SSHM Temperature	+50	+45	-5	-10
4:16	FDM SSHM Temperature	+50	+45	-5	-10
4:17	Structure 1 Temperature	+40	+35	-25	-30
4:18	Structure 2 Temperature	+40	+35	-25	-30
4:19	Structure 3 Temperature	+40	+35	-25	-30
4:20	Processor Module Temperature	+75	+65	-5	-10
4:21	Main DC/DC Converter Module Temp.	+77	+67	-5	-10
4:22	SCE RDM Module Temperature	+76	+66	-5	-10
4:23	SCE FDM Module Temperature	+76	+66	-5	-10
4:24	RF DC/DC Converter Module Temp.	+67	+57	-5	-10

Figure 18.5-67C. Temperature Limits, Standby, Scan, Fixed View

18.5.14 CONSTRAINTS

18.5.14.1 Pre-Launch

18.5.14.1.1 EMI – Flash Photography

The use of flash photography within the vicinity of the MHS is strictly forbidden. The Down-converter diodes used in the receiver are susceptible to energy levels as output by flash guns used for photography.

18.5.14.1.2 Temperature/Humidity Constraints

The ambient environment constraints for test and storage are as shown below.

(a) Integration and Test and Maintenance:
Temperature +20 ± 2°C
Humidity 35 to 65%

(b) Storage and transportation in the instrument container:
Temperature (outside container) -30 to +70°C
Humidity (outside container) Up to 100% RH*
*Beyond 60% RH the instrument must be double bagged using anti-static material inside the container.

18.5.14.1.3 Cleanliness

All spacecraft tests shall be performed in a Class 100,000 clean room environment except for acoustics, pyrotechnic shock, and thermal vacuum preparations. For these operations/tests, the instrument shall utilize anti-static covers.

18.5.14.2 Launch

The instrument shall be Off, the Reflector drum rotated to the OBCT position and the Survival Heaters Off.

18.5.14.3 Operational Exceptions

This section describes general constraints and limitations of the operation of the MHS Instrument. The routine procedures described in the MICROWAVE HUMIDITY SOUNDER (MHS) FLIGHT OPERATIONS MANUAL, MHS-OM-JA215-MMP, have been written taking into account these constraints. Therefore, these constraints will never cause a problem if the procedures are followed. They are included here for reference in case new procedures are developed in the future.

The following constraints should be noted:-

- It is possible for the LO redundancies not to be set up in accordance with the ICT on the Power-on to Warm-up transition under the following conditions:-
  - In Power-on Mode a Rx channel is switched on with LO A selected.
  - The ICT defines LO B.
  - On the transition to Warm-up Mode, the select LO B will not be executed because this is an illegal command when the channel is on.
- It is possible that the reception of an illegal command may not be reported in the Telecommand and Acknowledgement Field of the next packet, but one packet later. The first packet after the illegal command will indicate TC Received Count=2, Legal=1, and the following packet will indicate TC Received Count=1, Legal=0. This will depend on the exact timing of command reception and whether the software has had chance to process the command before outputting the next packet.
- The Fine Time Code value in the packet header is occasionally 5556 hex instead of 5555 hex. (1 LSB=2^{-16} seconds)
- Extended and normal Memory Packets : Time Code out by one scan period.
- The time code in Memory Data Packets and Extended Memory Data Packets may be up to ±1 scan period different to the actual time that the data was read.
- An attempt to enter Standby Mode from Warm-up Mode with the SPE/SCE off will cause a 'BIM error' (ie. EE internal intermodule bus error) and cause a transition into Fault Mode (TBC). Note that if Automatic Mode Transitions are selected in Power-on or Warm-up mode, then the Warm-up to Standby transition can occur automatically.
- Mode Transitions (eg. return from self-test): packet has HK data instead of test data, mode code = self-test.
- On mode transitions, it is possible for one packet to be generated with some of the data fields set to zero.
- On the Standby to Scan Mode transition, it is possible that a packet is not generated, causing two identical packets (with same time code) to be transferred.
- EM only: Main Bus switching (A to B, B to A) may fail if bus voltage is less than 28V.
- At switch-on, the Instrument may enter Fault Mode with the REF Clock Error Flag set (Fault Code). Recovery action => send Set Mode (Power-on) command.
- 'Pixel 1 Anomaly'. The first pixel reading of the first packet on entry to Fixed View Mode from Standby Mode is invalid.
- "Motor Position" or "Motor Current Demand" data equal to "FFFF" may be observed occasionally in Motor Self-Test Packets. These indicate a software overrun which is acceptable in Self-Test Mode. For post-processing purposes the "FFFF" may be replaced by the average of the two adjacent samples.

18.5.14.3.1 <u>Lifetime Constraints</u>

The following limitations due to the lifetime of components should be noted:-

- The relays within the Instrument should not be operated unnecessarily as they have a limited number of on/off cycles (1,000 in-flight design requirement, but typically 100,000 is achieved).

- The relays will perform one on/off cycle during a routine operation (Off to Scan Mode to Off). They are also operated during special operations in response to the Switch Command TC_SWC(CMD1:n), and during the TMTC Self-test Mode. In particular, the TMTC Self-Test Mode should not be selected with the 'repeat on' feature otherwise the relays will be cycled continuously at about 0.5Hz.

APPENDIX A : Instrument Configuration Table (ICT)

The ICT defines parameters related to the ON/OFF and redundancy configuration of the Instrument. It also defines parameters used by the Self-Test modes.

Table Reference = 0

Data Ref	Octet	Parameter Name	Definition	Default (in PROM)		Verification (read memory)	
				Value (hex)	Value (Engineering)	Address (hex)	Format
0	1	Mode Change Control	00 hex = manual FF hex = auto	00	Manual	14FDF (MS)	8 bit integer
	2	Operational Heater Control	00 hex = manual FF hex = auto	00	Manual	14FDF (LS)	8 bit integer
	3	DC Offset Control	00 hex = manual FF hex = auto	00	Manual	14FE0 (MS)	8 bit integer
	4	Telemetry Checking Control	bit 0 (MSB) : Thermistor checking bit 1 : Switch status checking bit 2 : Current Tlm checking bits 3..7(LSB) : unused 0 = checking OFF 1 = checking ON	E0	All Tlm checking on	14FE0 (LS)	8 bit flags
1	1	HL Commands 1	1:1 (MSB) to 1:8 (LSB)	AA	H1 & H2 on LO A	14FE1 (MS)	8 bit flags
	2	HL Commands 2	1:9 (MSB) to 1:16 (LSB)	AA	H3 & H4 on LO A	14FE1 (LS)	8 bit flags
	3	HL Commands 3	1:17 (MSB) to 1:24 (LSB)	AA	H5 on, LO A, RFCV On, H1 Gain =0dB	14FE2 (MS)	8 bit flags
	4	HL Commands 4	1:25 (MSB) to 1:32 (LSB)	49	H2, H3, H4 Gains = 0dB	14FE2 (LS)	8 bit flags
2	1	HL Commands 5	1:33 (MSB) to 1:37 (3 LSBs unused)	20	H5 Gain = 0dB	14FE3 (MS)	8 bit flags
	2	Rx Heater Redundancy Selection	bit 0 (MSB) = 0 : use Rx Op Htrs bit 0 = 1 : use Aux Op Htrs bits 1 to 15 : unused	00	Use Rx Heaters	14FE3 (LS)	8 bit flags
	3	unused	-	00	N/A	14FE4 (MS)	N/A
	4	unused	-	00	N/A	14FE4 (LS)	N/A

Data Ref	Octet	Parameter Name	Definition	Default (in PROM)		Verification (read memory)	
3	1	BIM Commands 1	3:1 (MSB) to 3:8 (LSB)	E1	SPE nominal RDM motor on, sensors side A	14FE5 (MS)	8 bit flags
	2	BIM commands 2	3:9 (MSB) to 3:11 (5 LSBs not used)	80	FDM motor on Sensors side A	14FE5 (LS)	8 bit flags
	3	unused	-	00	N/A	14FE6 (MS)	N/A
	4	unused	-	00	N/A	14FE6 (LS)	N/A
4	1	PIE Memory Test	00 hex = do test FF hex = do not do test	00	Do test	14FE7 (MS)	8 bit integer
	2	PIE Processor Test	00 hex = do test FF hex = do not do test	00	Do test	14FE7 (LS)	8 bit integer
	3	PIE TMTC Test	00 hex = do test FF hex = do not do test	00	Do test	14FE8 (MS)	8 bit integer
	4	unused	-	00	N/A	14FE8 (LS)	N/A
5	1	Memory Self Test	Start Address (A23..16)	01	Start address = 013004 (Scan Profile Table)	14FE9 (MS)	24 bit integer
	2	Memory Self Test	Start Address (A15..8)	30		14FE9 (LS)	
	3	Memory Self Test	Start Address (A7..0)	04		14FEA (MS)	
	4	Memory Self Test	End Address (A23..16)	01	End Address = 014683	14FEA (LS)	24 bit integer
6	1	Memory Self Test	End Address (A15..8)	46		14FEB (MS)	
	2	Memory Self Test	End Address (A7..0)	83		14FEB (LS)	
	3	Memory Self Test	Test Pattern (MS)	AA	Test Pattern = AAAA	14FEC (MS)	16 bit integer
	4	Memory Self Test	Test Pattern (LS)	AA		14FEC (LS)	
7	1	Memory Self Test	No. of errors (MS)	00	No of errors =1	14FED (MS)	16 bit integer
	2	Memory Self Test	No. of errors (LS)	01		14FED (LS)	
	3	Fixed Pattern Self Test	Data Pattern	55	Test Pattern = 55	14FEE (MS)	8 bit integer
	4	unused	-	00	N/A	14FEE (LS)	N/A

Data Ref	Octet	Parameter Name	Definition	Default (in PROM)		Verification (read memory)	
8	1	Motor Test	bit 0 (MSB): RDM drive enable (1) / disable (0) bit 1: FDM drive enable (1) / disable (0) bit 2: Store RDM (1) / FDM (0) data bit 3: Store position (1) / current demand (0) data bit 4: algorithm type: 0 = scan algorithm 1 = see bit 6 bit 5 : Position Data Precision 0 = 16 bit precision 1 = pseudo 18 bit precision bit 6 : only applies if bit 4 is set 0 = constant vel. algorithm 1 = fixed view algorithm bit 7 : unused	F0	RDM Enabled FDM Enabled Store RDM Data Store Position Data Scan Algorithm 16 bit precision	14FEF (MS)	8 bit flags
	2	Motor Test	Start COUNT (MS)	00	Start Count = 0	14FEF (LS)	16 bit integer
	3	Motor Test	Start COUNT (LS)	00		14FF0 (MS)	
	4	Motor Test	Constant velocity value 1 LSB = 5°/sec	0C	60 deg/sec	14FF0 (LS)	8 bit integer

APPENDIX B : Telemetry Limits Table (TLT)

The TLT defines limits against which telemetry channels are compared as part of the normal health monitoring of the Instrument. It also defines parameters which control the automatic mode switching functions (if enabled) and automatic heater control (if enabled).

Monitoring is performed on thermistor telemetry, current telemetry and switch status telemetry. The TLT defines the limits for thermistor and current telemetries.

Two levels of limits are defined. Firstly, 'warning' limits are levels which represent the expected worst case boundaries for each telemetry channel. If a channel goes outside of the warning limits, an error flag is raised in the Fault Code field of the HK Telemetry Packet, and the Instrument continues to operate in the same mode. Secondly, 'fault' limits are levels which represent the extreme values for which safe operation of the Instrument can continue. If a channel goes outside the fault limits, an error flag is raised in the Fault Code field of the HK Telemetry Packet and the instrument switches to Fault Mode. In Fault Mode, the necessary actions are taken to minimise the risk of damage to the instrument.

An upper level and a lower level are defined for both warning limits and fault limits, and for both temperature and current telemetry. The actions taken for exceeding either the upper or lower limit on either type of telemetry are the same. (Note: for thermistors, the upper limit defines the upper resistance threshold, which corresponds to the lower temperature threshold. This is because the thermistors have a negative temperature coefficient and the telemetry value is proportional to thermistor resistance.)

The warning and/or fault limit monitoring can be effectively 'disabled' by setting the upper and lower limits to FSR and zero respectively. In addition, parameter 0:4 of the ICT (Appendix A) allows global enabling/disabling of monitoring on each type of telemetry.

The TLT also defines temperature levels at which automatic mode transitions (if enabled by ICT parameter 0:1) occur. Levels are given for each temperature channel, and for the Power-on to Warm-up transition (tr1) and Warm-up to Standby transition (tr2). When all temperature telemetry channels exceed the given levels, the Instrument automatically switches to the next mode. In addition, timeout durations are given for each automatic transition. If the timeout period is exceeded then the Instrument automatically switches mode, irrespective of the telemetry values.

Automatic control of the Operational Heaters is achieved (when enabled by ICT parameter 0:2) using the upper and lower warning temperature limits. If any temperature of an equipment falls below the lower warning level then the corresponding heater is switched on. If any temperature of an equipment rises above the upper warning level then the corresponding heater is switched off. If one channel of an equipment is above the upper limit, and another channel of the same equipment is below the lower limit, then no action is taken (a fault flag will have been raised and the ground must take any appropriate action).

Note: no limit monitoring or automatic mode changes are based on the OBCT temperatures. These telemetry channels are only used for scientific data analysis.

Telemetry Limits Table (TLT)

Table Ref: 1

All temperature and current parameters are digital codes (ie. not engineering units) which correspond directly to the digital telemetry code as reported in the telemetry data in the HK Telemetry Packet and Science Data Packet.

NOTE: The 'high' limit refers to the upper limit of resistance of the thermistor, which corresponds to the lower temperature limit. (Thermistors have negative temperature coefficient.)

Refer to more notes at end of table.

Data Ref	Octet	Name (see notes at end of table)	Default (in PROM)		Verification (read memory)	
			Value (hex)	**Value (Engineering)**	**Address (hex)**	**Format**
0	1	Unused	N/A	N/A	N/A	N/A
	2	Unused	N/A	N/A	N/A	N/A
	3	Unused	N/A	N/A	N/A	N/A
	4	Unused	N/A	N/A	N/A	N/A
1	1	T1_m1_fault_high	FE	-35.5°C	10500 (MS)	8 bit integer
	2	T1_m1_warn_high	FD	-33.4°C	10500 (LS)	8 bit integer
	3	T1_m1_warn_low	42	+55°C	10501 (MS)	8 bit integer
	4	T1_m1_fault_low	3A	+60°C	10501 (LS)	8 bit integer
2	1	T2_m1_fault_high	FE	-35.5°C	10502 (MS)	8 bit integer
	2	T2_m1_warn_high	FD	-33.4°C	10502 (LS)	8 bit integer
	3	T2_m1_warn_low	42	+55°C	10503 (MS)	8 bit integer
	4	T2_m1_fault_low	3A	+60°C	10503 (LS)	8 bit integer
3	1	T3_m1_fault_high	FE	-35.5°C	10504 (MS)	8 bit integer
	2	T3_m1_warn_high	FD	-33.4°C	10504 (LS)	8 bit integer
	3	T3_m1_warn_low	42	+55°C	10505 (MS)	8 bit integer
	4	T3_m1_fault_low	3A	+60°C	10505(LS)	8 bit integer
4	1	T4_m1_fault_high	FE	-35.5°C	10506 (MS)	8 bit integer
	2	T4_m1_warn_high	FD	-33.4°C	10506 (LS)	8 bit integer
	3	T4_m1_warn_low	42	+55°C	10507 (MS)	8 bit integer
	4	T4_m1_fault_low	3A	+60°C	10507 (LS)	8 bit integer

Data Ref	Octet	Name (see notes at end of table)	Default (in PROM)		Verification (read memory)	
5	1	T5_m1_fault_high	FE	-35.5°C	10508 (MS)	8 bit integer
	2	T5_m1_warn_high	FD	-33.4°C	10508 (LS)	8 bit integer
	3	T5_m1_warn_low	42	+55°C	10509 (MS)	8 bit integer
	4	T5_m1_fault_low	3A	+60°C	10509 (LS)	8 bit integer
6	1	T6_m1_fault_high	FE	-35.5°C	1050A (MS)	8 bit integer
	2	T6_m1_warn_high	FD	-33.4°C	1050A (LS)	8 bit integer
	3	T6_m1_warn_low	42	+55°C	1050B (MS)	8 bit integer
	4	T6_m1_fault_low	3A	+60°C	1050B (LS)	8 bit integer
7	1	T7_m1_fault_high	FE	-35.5°C	1050C (MS)	8 bit integer
	2	T7_m1_warn_high	FD	-33.4°C	1050C (LS)	8 bit integer
	3	T7_m1_warn_low	42	+55°C	1050D (MS)	8 bit integer
	4	T7_m1_fault_low	3A	+60°C	1050D (LS)	8 bit integer
8	1	T8_m1_fault_high	FE	-35.5°C	1050E (MS)	8 bit integer
	2	T8_m1_warn_high	FD	-33.4°C	1050E (LS)	8 bit integer
	3	T8_m1_warn_low	42	+55°C	1050F (MS)	8 bit integer
	4	T8_m1_fault_low	3A	+60°C	1050F (LS)	8 bit integer
9	1	T9_m1_fault_high	FE	-35.5°C	10510 (MS)	8 bit integer
	2	T9_m1_warn_high	FD	-33.4°C	10510 (LS)	8 bit integer
	3	T9_m1_warn_low	42	+55°C	10511 (MS)	8 bit integer
	4	T9_m1_fault_low	3A	+60°C	10511 (LS)	8 bit integer
10	1	T10_m1_fault_high	FE	-35.5°C	10512 (MS)	8 bit integer
	2	T10_m1_warn_high	FD	-33.4°C	10512 (LS)	8 bit integer
	3	T10_m1_warn_low	42	+55°C	10513 (MS)	8 bit integer
	4	T10_m1_fault_low	3A	+60°C	10513 (LS)	8 bit integer
11	1	T11_m1_fault_high	FE	-35.5°C	10514 (MS)	8 bit integer
	2	T11_m1_warn_high	FD	-33.4°C	10514 (LS)	8 bit integer
	3	T11_m1_warn_low	42	+55°C	10515 (MS)	8 bit integer
	4	T11_m1_fault_low	3A	+60°C	10515 (LS)	8 bit integer
12	1	T12_m1_fault_high	FE	-35.5°C	10516 (MS)	8 bit integer
	2	T12_m1_warn_high	FD	-33.4°C	10516 (LS)	8 bit integer
	3	T12_m1_warn_low	42	+55°C	10517 (MS)	8 bit integer
	4	T12_m1_fault_low	3A	+60°C	10517 (LS)	8 bit integer

Data Ref	Octet	Name (see notes at end of table)	Default (in PROM)		Verification (read memory)	
13	1	T13_m1_fault_high	FE	-35.5°C	10518 (MS)	8 bit integer
	2	T13_m1_warn_high	FD	-33.4°C	10518 (LS)	8 bit integer
	3	T13_m1_warn_low	55	+45°C	10519 (MS)	8 bit integer
	4	T13_m1_fault_low	4B	+50°C	10519 (LS)	8 bit integer
14	1	T14_m1_fault_high	FE	-35.5°C	1051A (MS)	8 bit integer
	2	T14_m1_warn_high	FD	-33.4°C	1051A (LS)	8 bit integer
	3	T14_m1_warn_low	55	+45°C	1051B (MS)	8 bit integer
	4	T14_m1_fault_low	4B	+50°C	1051B (LS)	8 bit integer
15	1	T15_m1_fault_high	FE	-35.5°C	1051C (MS)	8 bit integer
	2	T15_m1_warn_high	FD	-33.4°C	1051C (LS)	8 bit integer
	3	T15_m1_warn_low	55	+45°C	1051D (MS)	8 bit integer
	4	T15_m1_fault_low	4B	+50°C	1051D (LS)	8 bit integer
16	1	T16_m1_fault_high	FE	-35.5°C	1051E (MS)	8 bit integer
	2	T16_m1_warn_high	FD	-33.4°C	1051E (LS)	8 bit integer
	3	T16_m1_warn_low	55	+45°C	1051F (MS)	8 bit integer
	4	T16_m1_fault_low	4B	+50°C	1051F (LS)	8 bit integer
17	1	T17_m1_fault_high	FE	-35.5°C	10520 (MS)	8 bit integer
	2	T17_m1_warn_high	FD	-33.4°C	10520 (LS)	8 bit integer
	3	T17_m1_warn_low	42	+55°C	10521 (MS)	8 bit integer
	4	T17_m1_fault_low	3A	+60°C	10521 (LS)	8 bit integer
18	1	T18_m1_fault_high	FE	-35.5°C	10522 (MS)	8 bit integer
	2	T18_m1_warn_high	FD	-33.4°C	10522 (LS)	8 bit integer
	3	T18_m1_warn_low	42	+55°C	10523 (MS)	8 bit integer
	4	T18_m1_fault_low	3A	+60°C	10523 (LS)	8 bit integer
19	1	T19_m1_fault_high	FE	-35.5°C	10524 (MS)	8 bit integer
	2	T19_m1_warn_high	FD	-33.4°C	10524 (LS)	8 bit integer
	3	T19_m1_warn_low	42	+55°C	10525 (MS)	8 bit integer
	4	T19_m1_fault_low	3A	+60°C	10525 (LS)	8 bit integer
20	1	T20_m1_fault_high	F6	-25°C	10526 (MS)	8 bit integer
	2	T20_m1_warn_high	EC	-20°C	10526 (LS)	8 bit integer
	3	T20_m1_warn_low	33	+65°C	10527 (MS)	8 bit integer
	4	T20_m1_fault_low	28	+75°C	10527 (LS)	8 bit integer

Data Ref	Octet	Name (see notes at end of table)	Default (in PROM)		Verification (read memory)	
21	1	T21_m1_fault_high	F6	-25°C	10528 (MS)	8 bit integer
	2	T21_m1_warn_high	EC	-20°C	10528 (LS)	8 bit integer
	3	T21_m1_warn_low	30	+67°C	10529 (MS)	8 bit integer
	4	T21_m1_fault_low	25	+77°C	10529 (LS)	8 bit integer
22	1	T22_m1_fault_high	F6	-25°C	1052A (MS)	8 bit integer
	2	T22_m1_warn_high	EC	-20°C	1052A (LS)	8 bit integer
	3	T22_m1_warn_low	31	+66°C	1052B (MS)	8 bit integer
	4	T22_m1_fault_low	26	+76°C	1052B (LS)	8 bit integer
23	1	T23_m1_fault_high	F6	-25°C	1052C (MS)	8 bit integer
	2	T23_m1_warn_high	EC	-20°C	1052C (LS)	8 bit integer
	3	T23_m1_warn_low	31	+66°C	1052D (MS)	8 bit integer
	4	T23_m1_fault_low	26	+76°C	1052D (LS)	8 bit integer
24	1	T24_m1_fault_high	F6	-25°C	1052E (MS)	8 bit integer
	2	T24_m1_warn_high	EC	-20°C	1052E (LS)	8 bit integer
	3	T24_m1_warn_low	3E	+57°C	1052F (MS)	8 bit integer
	4	T24_m1_fault_low	30	+67°C	1052F (LS)	8 bit integer
25	1	T1_m2_fault_high	F6	-25°C	10530 (MS)	8 bit integer
	2	T1_m2_warn_high	EC	-20°C	10530 (LS)	8 bit integer
	3	T1_m2_warn_low	55	+45°C	10531 (MS)	8 bit integer
	4	T1_m2_fault_low	4B	+50°C	10531 (LS)	8 bit integer
26	1	T2_m2_fault_high	F6	-25°C	10532 (MS)	8 bit integer
	2	T2_m2_warn_high	EC	-20°C	10532 (LS)	8 bit integer
	3	T2_m2_warn_low	55	+45°C	10533 (MS)	8 bit integer
	4	T2_m2_fault_low	4B	+50°C	10533 (LS)	8 bit integer
27	1	T3_m2_fault_high	F6	-25°C	10534 (MS)	8 bit integer
	2	T3_m2_warn_high	EC	-20°C	10534 (LS)	8 bit integer
	3	T3_m2_warn_low	55	+45°C	10535 (MS)	8 bit integer
	4	T3_m2_fault_low	4B	+50°C	10535 (LS)	8 bit integer
28	1	T4_m2_fault_high	F6	-25°C	10536 (MS)	8 bit integer
	2	T4_m2_warn_high	EC	-20°C	10536 (LS)	8 bit integer
	3	T4_m2_warn_low	55	+45°C	10537 (MS)	8 bit integer
	4	T4_m2_fault_low	4B	+50°C	10537 (LS)	8 bit integer

Data Ref	Octet	Name (see notes at end of table)	Default (in PROM)		Verification (read memory)	
29	1	T5_m2_fault_high	F6	-25°C	10538 (MS)	8 bit integer
	2	T5_m2_warn_high	EC	-20°C	10538 (LS)	8 bit integer
	3	T5_m2_warn_low	55	+45°C	10539 (MS)	8 bit integer
	4	T5_m2_fault_low	4B	+50°C	10539 (LS)	8 bit integer
30	1	T6_m2_fault_high	F6	-25°C	1053A (MS)	8 bit integer
	2	T6_m2_warn_high	EC	-20°C	1053A (LS)	8 bit integer
	3	T6_m2_warn_low	55	+45°C	1053B (MS)	8 bit integer
	4	T6_m2_fault_low	4B	+50°C	1053B (LS)	8 bit integer
31	1	T7_m2_fault_high	F6	-25°C	1053C (MS)	8 bit integer
	2	T7_m2_warn_high	EC	-20°C	1053C (LS)	8 bit integer
	3	T7_m2_warn_low	55	+45°C	1053D (MS)	8 bit integer
	4	T7_m2_fault_low	4B	+50°C	1053D (LS)	8 bit integer
32	1	T8_m2_fault_high	F6	-25°C	1053E (MS)	8 bit integer
	2	T8_m2_warn_high	EC	-20°C	1053E (LS)	8 bit integer
	3	T8_m2_warn_low	55	+45°C	1053F (MS)	8 bit integer
	4	T8_m2_fault_low	4B	+50°C	1053F (LS)	8 bit integer
33	1	T9_m2_fault_high	F6	-25°C	10540 (MS)	8 bit integer
	2	T9_m2_warn_high	EC	-20°C	10540 (LS)	8 bit integer
	3	T9_m2_warn_low	55	+45°C	10541 (MS)	8 bit integer
	4	T9_m2_fault_low	4B	+50°C	10541 (LS)	8 bit integer
34	1	T10_m2_fault_high	F6	-25°C	10542 (MS)	8 bit integer
	2	T10_m2_warn_high	EC	-20°C	10542 (LS)	8 bit integer
	3	T10_m2_warn_low	55	+45°C	10543 (MS)	8 bit integer
	4	T10_m2_fault_low	4B	+50°C	10543 (LS)	8 bit integer
35	1	T11_m2_fault_high	F6	-25°C	10544 (MS)	8 bit integer
	2	T11_m2_warn_high	EC	-20°C	10544 (LS)	8 bit integer
	3	T11_m2_warn_low	55	+45°C	10545 (MS)	8 bit integer
	4	T11_m2_fault_low	4B	+50°C	10545 (LS)	8 bit integer
36	1	T12_m2_fault_high	F6	-25°C	10546 (MS)	8 bit integer
	2	T12_m2_warn_high	EC	-20°C	10546 (LS)	8 bit integer
	3	T12_m2_warn_low	55	+45°C	10547 (MS)	8 bit integer
	4	T12_m2_fault_low	4B	+50°C	10547 (LS)	8 bit integer

Data Ref	Octet	Name (see notes at end of table)	Default (in PROM)		Verification (read memory)	
37	1	T13_m2_fault_high	FE	-40°C	10548 (MS)	8 bit integer
	2	T13_m2_warn_high	FD	-35°C	10548 (LS)	8 bit integer
	3	T13_m2_warn_low	55	+45°C	10549 (MS)	8 bit integer
	4	T13_m2_fault_low	4B	+50°C	10549 (LS)	8 bit integer
38	1	T14_m2_fault_high	FE	-40°C	1054A (MS)	8 bit integer
	2	T14_m2_warn_high	FD	-35°C	1054A (LS)	8 bit integer
	3	T14_m2_warn_low	55	+45°C	1054B (MS)	8 bit integer
	4	T14_m2_fault_low	4B	+50°C	1054B (LS)	8 bit integer
39	1	T15_m2_fault_high	FE	-40°C	1054C (MS)	8 bit integer
	2	T15_m2_warn_high	FD	-35°C	1054C (LS)	8 bit integer
	3	T15_m2_warn_low	55	+45°C	1054D (MS)	8 bit integer
	4	T15_m2_fault_low	4B	+50°C	1054D (LS)	8 bit integer
40	1	T16_m2_fault_high	FE	-40°C	1054E (MS)	8 bit integer
	2	T16_m2_warn_high	FD	-35°C	1054E (LS)	8 bit integer
	3	T16_m2_warn_low	55	+45°C	1054F (MS)	8 bit integer
	4	T16_m2_fault_low	4B	+50°C	1054F (LS)	8 bit integer
41	1	T17_m2_fault_high	FE	-40°C	10550 (MS)	8 bit integer
	2	T17_m2_warn_high	FD	-35°C	10550 (LS)	8 bit integer
	3	T17_m2_warn_low	42	+55°C	10551 (MS)	8 bit integer
	4	T17_m2_fault_low	3A	+60°C	10551 (LS)	8 bit integer
42	1	T18_m2_fault_high	FE	-40°C	10552 (MS)	8 bit integer
	2	T18_m2_warn_high	FD	-35°C	10552 (LS)	8 bit integer
	3	T18_m2_warn_low	42	+55°C	10553 (MS)	8 bit integer
	4	T18_m2_fault_low	3A	+60°C	10553 (LS)	8 bit integer
43	1	T19_m2_fault_high	FE	-40°C	10554 (MS)	8 bit integer
	2	T19_m2_warn_high	FD	-35°C	10554 (LS)	8 bit integer
	3	T19_m2_warn_low	42	+55°C	10555 (MS)	8 bit integer
	4	T19_m2_fault_low	3A	+60°C	10555 (LS)	8 bit integer
44	1	T20_m2_fault_high	F6	-25°C	10556 (MS)	8 bit integer
	2	T20_m2_warn_high	EC	-20°C	10556 (LS)	8 bit integer
	3	T20_m2_warn_low	33	+65°C	10557 (MS)	8 bit integer
	4	T20_m2_fault_low	28	+75°C	10557 (LS)	8 bit integer

Data Ref	Octet	Name (see notes at end of table)	Default (in PROM)		Verification (read memory)	
45	1	T21_m2_fault_high	F6	-25°C	10558 (MS)	8 bit integer
	2	T21_m2_warn_high	EC	-20°C	10558 (LS)	8 bit integer
	3	T21_m2_warn_low	30	+67°C	10559 (MS)	8 bit integer
	4	T21_m2_fault_low	25	+77°C	10559 (LS)	8 bit integer
46	1	T22_m2_fault_high	F6	-25°C	1055A (MS)	8 bit integer
	2	T22_m2_warn_high	EC	-20°C	1055A (LS)	8 bit integer
	3	T22_m2_warn_low	31	+66°C	1055B (MS)	8 bit integer
	4	T22_m2_fault_low	26	+76°C	1055B (LS)	8 bit integer
47	1	T23_m2_fault_high	F6	-25°C	1055C (MS)	8 bit integer
	2	T23_m2_warn_high	EC	-20°C	1055C (LS)	8 bit integer
	3	T23_m2_warn_low	31	+66°C	1055D (MS)	8 bit integer
	4	T23_m2_fault_low	26	+76°C	1055D (LS)	8 bit integer
48	1	T24_m2_fault_high	F6	-25°C	1055E (MS)	8 bit integer
	2	T24_m2_warn_high	EC	-20°C	1055E (LS)	8 bit integer
	3	T24_m2_warn_low	3E	+57°C	1055F (MS)	8 bit integer
	4	T24_m2_fault_low	30	+67°C	1055F (LS)	8 bit integer
49	1	T1_m3_fault_high	AD	+10°C	10560 (MS)	8 bit integer
	2	T1_m3_warn_high	A1	+15°C	10560 (LS)	8 bit integer
	3	T1_m3_warn_low	6C	+35°C	10561 (MS)	8 bit integer
	4	T1_m3_fault_low	60	+40°C	10561 (LS)	8 bit integer
50	1	T2_m3_fault_high	AD	+10°C	10562 (MS)	8 bit integer
	2	T2_m3_warn_high	A1	+15°C	10562 (LS)	8 bit integer
	3	T2_m3_warn_low	6C	+35°C	10563 (MS)	8 bit integer
	4	T2_m3_fault_low	60	+40°C	10563 (LS)	8 bit integer
51	1	T3_m3_fault_high	AD	+10°C	10564 (MS)	8 bit integer
	2	T3_m3_warn_high	A1	+15°C	10564 (LS)	8 bit integer
	3	T3_m3_warn_low	6C	+35°C	10565 (MS)	8 bit integer
	4	T3_m3_fault_low	60	+40°C	10565 (LS)	8 bit integer
52	1	T4_m3_fault_high	AD	+10°C	10566 (MS)	8 bit integer
	2	T4_m3_warn_high	A1	+15°C	10566 (LS)	8 bit integer
	3	T4_m3_warn_low	6C	+35°C	10567 (MS)	8 bit integer
	4	T4_m3_fault_low	60	+40°C	10567 (LS)	8 bit integer

Data Ref	Octet	Name (see notes at end of table)	Default (in PROM)		Verification (read memory)	
53	1	T5_m3_fault_high	AD	+10°C	10568 (MS)	8 bit integer
	2	T5_m3_warn_high	A1	+15°C	10568 (LS)	8 bit integer
	3	T5_m3_warn_low	6C	+35°C	10569 (MS)	8 bit integer
	4	T5_m3_fault_low	60	+40°C	10569 (LS)	8 bit integer
54	1	T6_m3_fault_high	AD	+10°C	1056A (MS)	8 bit integer
	2	T6_m3_warn_high	A1	+15°C	1056A (LS)	8 bit integer
	3	T6_m3_warn_low	6C	+35°C	1056B (MS)	8 bit integer
	4	T6_m3_fault_low	60	+40°C	1056B (LS)	8 bit integer
55	1	T7_m3_fault_high	AD	+10°C	1056C (MS)	8 bit integer
	2	T7_m3_warn_high	A1	+15°C	1056C (LS)	8 bit integer
	3	T7_m3_warn_low	6C	+35°C	1056D (MS)	8 bit integer
	4	T7_m3_fault_low	60	+40°C	1056D (LS)	8 bit integer
56	1	T8_m3_fault_high	AD	+10°C	1056E (MS)	8 bit integer
	2	T8_m3_warn_high	A1	+15°C	1056E (LS)	8 bit integer
	3	T8_m3_warn_low	6C	+35°C	1056F (MS)	8 bit integer
	4	T8_m3_fault_low	60	+40°C	1056F (LS)	8 bit integer
57	1	T9_m3_fault_high	AD	+10°C	10570 (MS)	8 bit integer
	2	T9_m3_warn_high	A1	+15°C	10570 (LS)	8 bit integer
	3	T9_m3_warn_low	6C	+35°C	10571 (MS)	8 bit integer
	4	T9_m3_fault_low	60	+40°C	10571 (LS)	8 bit integer
58	1	T10_m3_fault_high	AD	+10°C	10572 (MS)	8 bit integer
	2	T10_m3_warn_high	A1	+15°C	10572 (LS)	8 bit integer
	3	T10_m3_warn_low	6C	+35°C	10573 (MS)	8 bit integer
	4	T10_m3_fault_low	60	+40°C	10573 (LS)	8 bit integer
59	1	T11_m3_fault_high	AD	+10°C	10574 (MS)	8 bit integer
	2	T11_m3_warn_high	A1	+15°C	10574 (LS)	8 bit integer
	3	T11_m3_warn_low	6C	+35°C	10575 (MS)	8 bit integer
	4	T11_m3_fault_low	60	+40°C	10575 (LS)	8 bit integer
60	1	T12_m3_fault_high	AD	+10°C	10576 (MS)	8 bit integer
	2	T12_m3_warn_high	A1	+15°C	10576 (LS)	8 bit integer
	3	T12_m3_warn_low	6C	+35°C	10577 (MS)	8 bit integer
	4	T12_m3_fault_low	60	+40°C	10577 (LS)	8 bit integer

Data Ref	Octet	Name (see notes at end of table)	Default (in PROM)		Verification (read memory)	
61	1	T13_m3_fault_high	DF	-10°C	10578 (MS)	8 bit integer
	2	T13_m3_warn_high	D3	-5°C	10578 (LS)	8 bit integer
	3	T13_m3_warn_low	55	+45°C	10579 (MS)	8 bit integer
	4	T13_m3_fault_low	4B	+50°C	10579 (LS)	8 bit integer
62	1	T14_m3_fault_high	DF	-10°C	1057A (MS)	8 bit integer
	2	T14_m3_warn_high	D3	-5°C	1057A (LS)	8 bit integer
	3	T14_m3_warn_low	55	+45°C	1057B (MS)	8 bit integer
	4	T14_m3_fault_low	4B	+50°C	1057B (LS)	8 bit integer
63	1	T15_m3_fault_high	DF	-10°C	1057C (MS)	8 bit integer
	2	T15_m3_warn_high	D3	-5°C	1057C (LS)	8 bit integer
	3	T15_m3_warn_low	55	+45°C	1057D (MS)	8 bit integer
	4	T15_m3_fault_low	4B	+50°C	1057D (LS)	8 bit integer
64	1	T16_m3_fault_high	DF	-10°C	1057E (MS)	8 bit integer
	2	T16_m3_warn_high	D3	-5°C	1057E (LS)	8 bit integer
	3	T16_m3_warn_low	55	+45°C	1057F (MS)	8 bit integer
	4	T16_m3_fault_low	4B	+50°C	1057F (LS)	8 bit integer
65	1	T17_m3_fault_high	FA	-30°C	10580 (MS)	8 bit integer
	2	T17_m3_warn_high	F6	-25°C	10580 (LS)	8 bit integer
	3	T17_m3_warn_low	6C	+35°C	10581 (MS)	8 bit integer
	4	T17_m3_fault_low	60	+40°C	10581 (LS)	8 bit integer
66	1	T18_m3_fault_high	FA	-30°C	10582 (MS)	8 bit integer
	2	T18_m3_warn_high	F6	-25°C	10582 (LS)	8 bit integer .
	3	T18_m3_warn_low	6C	+35°C	10583 (MS)	8 bit integer
	4	T18_m3_fault_low	60	+40°C	10583 (LS)	8 bit integer
67	1	T19_m3_fault_high	FA	-30°C	10584 (MS)	8 bit integer
	2	T19_m3_warn_high	F6	-25°C	10584 (LS)	8 bit integer
	3	T19_m3_warn_low	6C	+35°C	10585 (MS)	8 bit integer
	4	T19_m3_fault_low	60	+40°C	10585 (LS)	8 bit integer
68	1	T20_m3_fault_high	E0	-10°C	10586 (MS)	8 bit integer
	2	T20_m3_warn_high	D3	-5°C	10586 (LS)	8 bit integer
	3	T20_m3_warn_low	33	+65°C	10587 (MS)	8 bit integer
	4	T20_m3_fault_low	28	+75°C	10587 (LS)	8 bit integer

Data Ref	Octet	Name (see notes at end of table)	Default (in PROM)		Verification (read memory)	
69	1	T21_m3_fault_high	E0	-10°C	10588 (MS)	8 bit integer
	2	T21_m3_warn_high	D3	-5°C	10588 (LS)	8 bit integer
	3	T21_m3_warn_low	30	+67°C	10589 (MS)	8 bit integer
	4	T21_m3_fault_low	25	+77°C	10589 (LS)	8 bit integer
70	1	T22_m3_fault_high	E0	-10°C	1058A (MS)	8 bit integer
	2	T22_m3_warn_high	D3	-5°C	1058A (LS)	8 bit integer
	3	T22_m3_warn_low	31	+66°C	1058B (MS)	8 bit integer
	4	T22_m3_fault_low	26	+76°C	1058B (LS)	8 bit integer
71	1	T23_m3_fault_high	E0	-10°C	1058C (MS)	8 bit integer
	2	T23_m3_warn_high	D3	-5°C	1058C (LS)	8 bit integer
	3	T23_m3_warn_low	31	+66°C	1058D (MS)	8 bit integer
	4	T23_m3_fault_low	26	+76°C	1058D (LS)	8 bit integer
72	1	T24_m3_fault_high	E0	-10°C	1058E (MS)	8 bit integer
	2	T24_m3_warn_high	D3	-5°C	1058E (LS)	8 bit integer
	3	T24_m3_warn_low	3E	+57°C	1058F (MS)	8 bit integer
	4	T24_m3_fault_low	30	+67°C	1058F (LS)	8 bit integer
73	1	T1_tr1	EC	-20°C	10590 (MS)	8 bit integer
	2	T2_tr1	EC	-20°C	10593 (LS)	8 bit integer
	3	T3_tr1	EC	-20°C	10596 (MS)	8 bit integer
	4	T4_tr1	EC	-20°C	10599 (LS)	8 bit integer
74	1	T5_tr1	EC	-20°C	1059C (MS)	8 bit integer
	2	T6_tr1	EC	-20°C	1059F (LS)	8 bit integer
	3	T7_tr1	EC	-20°C	105A2 (MS)	8 bit integer
	4	T8_tr1	EC	-20°C	105A5 (LS)	8 bit integer
75	1	T9_tr1	EC	-20°C	105A8 (MS)	8 bit integer
	2	T10_tr1	EC	-20°C	105AB (LS)	8 bit integer
	3	T11_tr1	EC	-20°C	105AE (MS)	8 bit integer
	4	T12_tr1	EC	-20°C	105B1 (LS)	8 bit integer
76	1	T13_tr1	FD	-35°C	105B4 (MS)	8 bit integer
	2	T14_tr1	FD	-35°C	105B7 (LS)	8 bit integer
	3	T15_tr1	FD	-35°C	105BA (MS)	8 bit integer
	4	T16_tr1	FD	-35°C	105BD (LS)	8 bit integer

Data Ref	Octet	Name (see notes at end of table)	Default (in PROM)		Verification (read memory)	
77	1	T17_tr1	FD	-35°C	105C0 (MS)	8 bit integer
	2	T18_tr1	FD	-35°C	105C3 (LS)	8 bit integer
	3	T19_tr1	FD	-35°C	105C6 (MS)	8 bit integer
	4	T20_tr1	EC	-20°C	105C9 (LS)	8 bit integer
78	1	T21_tr1	EC	-20°C	105CC (MS)	8 bit integer
	2	T22_tr1	EC	-20°C	105CF (LS)	8 bit integer
	3	T23_tr1	EC	-20°C	105D2 (MS)	8 bit integer
	4	T24_tr1	EC	-20°C	105D5 (LS)	8 bit integer
79	1	T1_tr2	A0	+15°C	10591 (MS)	8 bit integer
	2	T2_tr2	A0	+15°C	10594 (LS)	8 bit integer
	3	T3_tr2	A0	+15°C	10597 (MS)	8 bit integer
	4	T4_tr2	A0	+15°C	1059A (LS)	8 bit integer
80	1	T5_tr2	A0	+15°C	1059D (MS)	8 bit integer
	2	T6_tr2	A0	+15°C	105A0 (LS)	8 bit integer
	3	T7_tr2	A0	+15°C	105A3 (MS)	8 bit integer
	4	T8_tr2	A0	+15°C	105A6 (LS)	8 bit integer
81	1	T9_tr2	A0	+15°C	105A9 (MS)	8 bit integer
	2	T10_tr2	A0	+15°C	105AC (LS)	8 bit integer
	3	T11_tr2	A0	+15°C	105AF (MS)	8 bit integer
	4	T12_tr2	A0	+15°C	105B2 (LS)	8 bit integer
82	1	T13_tr2	D3	-5°C	105B5 (MS)	8 bit integer
	2	T14_tr2	D3	-5°C	105B8 (LS)	8 bit integer
	3	T15_tr2	D3	-5°C	105BB (MS)	8 bit integer
	4	T16_tr2	D3	-5°C	105BE (LS)	8 bit integer
83	1	T17_tr2	F6	-25°C	105C1 (MS)	8 bit integer
	2	T18_tr2	F6	-25°C	105C4 (LS)	8 bit integer
	3	T19_tr2	F6	-25°C	105C7 (MS)	8 bit integer
	4	T20_tr2	D3	-5°C	105CA (LS)	8 bit integer
84	1	T21_tr2	D3	-5°C	105CD (MS)	8 bit integer
	2	T22_tr2	D3	-5°C	105D0 (LS)	8 bit integer
	3	T23_tr2	D3	-5°C	105D3 (MS)	8 bit integer
	4	T24_tr2	D3	-5°C	105D6 (LS)	8 bit integer

Data Ref	Octet	Name (see notes at end of table)	Default (in PROM)		Verification (read memory)	
85	1	time_tr1 (MS)	00	120 seconds	10627 (MS)	16 bit integer
	2	time_tr1 (LS)	78		10627 (LS)	
	3	time_tr2 (MS)	00	120 seconds	10628 (MS)	16 bit integer
	4	time_tr2 (LS)	78		10628 (LS)	
86	1	RDM1_fault_high	18	165mA	104E4 (MS)	8 bit integer
	2	RDM1_warn_high	10	110mA	104E4 (LS)	8 bit integer
	3	RDM1_warn_low	00	0mA	104E5 (MS)	8 bit integer
	4	RDM1_fault_low	00	0mA	104E5 (LS)	8 bit integer
87	1	RDM2_fault_high	16	152mA	104E6 (MS)	8 bit integer
	2	RDM2_warn_high	0E	96mA	104E6 (LS)	8 bit integer
	3	RDM2_warn_low	00	0mA	104E7 (MS)	8 bit integer
	4	RDM2_fault_low	00	0mA	104E7 (LS)	8 bit integer
88	1	RDM3_fault_high	74	799mA	104E8 (MS)	8 bit integer
	2	RDM3_warn_high	70	771mA	104E8 (LS)	8 bit integer
	3	RDM3_warn_low	52	565mA	104E9 (MS)	8 bit integer
	4	RDM3_fault_low	4D	530mA	104E9 (LS)	8 bit integer
89	1	FDM1_fault_high	18	165mA	10EEA (MS)	8 bit integer
	2	FDM1_warn_high	10	110mA	104EA (LS)	8 bit integer
	3	FDM1_warn_low	00	0mA	104EB (MS)	8 bit integer
	4	FDM1_fault_low	00	0mA	104EB (LS)	8 bit integer
90	1	FDM2_fault_high	16	152mA	104EC (MS)	8 bit integer
	2	FDM2_warn_high	0E	96mA	104EC (LS)	8 bit integer
	3	FDM2_warn_low	00	0mA	104ED (MS)	8 bit integer
	4	FDM2_fault_low	00	0mA	104ED (LS)	8 bit integer
91	1	FDM3_fault_high	74	799mA	104EE (MS)	8 bit integer
	2	FDM3_warn_high	70	771mA	104EE (LS)	8 bit integer
	3	FDM3_warn_low	52	565mA	104EF (MS)	8 bit integer
	4	FDM3_fault_low	4D	530mA	104EF (LS)	8 bit integer
92	1	EE1_fault_high	2E	773mA	104F0 (MS)	8 bit integer
	2	EE1_warn_high	2A	706mA	104F0 (LS)	8 bit integer
	3	EE1_warn_low	22	572mA	104F1 (MS)	8 bit integer
	4	EE1_fault_low	1E	504mA	104F1 (LS)	8 bit integer
93	1	EE2_fault_high	47	1194mA	104F2 (MS)	8 bit integer
	2	EE2_warn_high	41	1093mA	104F2 (LS)	8 bit integer

Data Ref	Octet	Name (see notes at end of table)	Default (in PROM)		Verification (read memory)	
	3	EE2_warn_low	2A	706mA	104F3 (MS)	8 bit integer
	4	EE2_fault_low	25	622mA	104F3 (LS)	8 bit integer
94	1	Rx8_off_fault_high	1B	595mA	104F4 (MS)	8 bit integer
	2	Rx8_off_warn_high	10	352mA	104F4 (LS)	8 bit integer
	3	Rx8_off_warn_low	00	0mA	104F5 (MS)	8 bit integer
	4	Rx8_off_fault_low	00	0mA	104F5 (LS)	8 bit integer
95	1	Rx8_on_fault_high	55	1874mA	104F6 (MS)	8 bit integer
	2	Rx8_on_warn_high	53	1830mA	104F6 (LS)	8 bit integer
	3	Rx8_on_warn_low	30	1058mA	104F7 (MS)	8 bit integer
	4	Rx8_on_fault_low	00	0mA	104F7 (LS)	8 bit integer
96	1	Rxp15_off_fault_high	20	258mA	104F8 (MS)	8 bit integer
	2	Rxp15_off_warn_high	14	161mA	104F8 (LS)	8 bit integer
	3	Rxp15_off_warn_low	00	0mA	104F9 (MS)	8 bit integer
	4		00	0mA	104F9 (LS)	8 bit integer
97	1	Rxp15_on_fault_high	7B	992mA	104FA (MS)	8 bit integer
	2	Rxp15_on_warn_high	73	927mA	104FA (LS)	8 bit integer
	3	Rxp15_on_warn_low	5B	734mA	104FB (MS)	8 bit integer
	4	Rxp15_on_fault_low	00	0mA	104FB (LS)	8 bit integer
98	1	Rxm15_off_fault_high	25	70mA	104FC (MS)	8 bit integer
	2	Rxm15_off_warn_high	1A	49mA	104FC (LS)	8 bit integer
	3	Rxm15_off_warn_low	00	0mA	104FD (MS)	8 bit integer
	4	Rxm15_off_fault_low	00	0mA	104FD (LS)	8 bit integer
99	1	Rxm15_on_fault_high	7F	239mA	104FE (MS)	8 bit integer
	2	Rxm15_on_warn_high	67	194mA	104FE (LS)	8 bit integer
	3	Rxm15_on_warn_low	4C	143mA	104FF (MS)	8 bit integer
	4	Rxm15_on_fault_low	00	0mA	104FF (LS)	8 bit integer

Notes:

1. Thermistor telemetry

Tn : Thermistor Channel n
low / high : low limit, high limit (corresponds to the thermistor resistance, therefore the low limit corresponds to high temperature, and the high limit corresponds to low temperature).
warn / fault : warning limit (set Fault Bit), fault limit (switch to Fault Mode)

Automatic heater control shall use the warning low and high limits as the switching points for the operational heaters:

Warning_low = high temperature threshold = heater switch off point
Warning_high = low temperature threshold = heater switch on point

m1/m2/m3 : mode dependency :-

Mode	applicable limits
Power-on	m1
Warm-up	m2
Standby	m3
Scan	m3
Fixed View	m3
Safeing	telemetry checking not required - automatically goes to Power-On Mode
Fault	telemetry checking not performed (Fault bits indicate the fault which caused the transition to Fault Mode)
Self-Test	limits same as calling mode

tr1/tr2 : mode transition dependency (for automatic mode transitions):-

tr1 : Power-on to Warm-up
tr2 : Warm-up to Standby
time defined in integer seconds.

2. Current Telemetry

The limits are mode dependent.

Mode	RDM Motor (5:1)	FDM Motor (5:2)	EE 5V (5:3)	RX +8V (5:4)	Rx +15V (5:5)	Rx -15V (5:6)
Power-on 1 (SPE/SCE OFF)	RDM1	FDM1	EE1	Rx8_off	Rxp15_off	Rxm15_off
Power-on 2 (SPE/SCE ON)	RDM1	FDM1	EE2	Rx8_off	Rxp15_off	Rxm15_off
Warm-up	RDM1	FDM1	EE2	Rx8_on	RXp15_on	Rxm15_on
Standby	RDM2	FDM2	EE2	Rx8_on	RXp15_on	Rxm15_on
Scan	RDM3	FDM3	EE2	Rx8_on	RXp15_on	Rxm15_on
Fixed View	RDM3	FDM3	EE2	Rx8_on	RXp15_on	Rxm15_on
Safeing	n/a	n/a	n/a	n/a	n/a	n/a
Fault	n/a	n/a	n/a	n/a	n/a	n/a
Self_Test (except motor)	same as calling mode					
Motor Self-Test	RDM3	FDM3	same as calling mode			

APPENDIX C : Scan Control Table (SCT)

The SCT defines parameters which are used by the Scan Control functions. It defines parameters such as:-

- Characterisation parameters for the Motors, Scan Drive Amplifiers, Inductosyn measurement system, Reflector/shroud/flywheel, etc.
- Algorithm gain parameters
- Profile definition parameters
- Initialisation parameters
- Performance monitoring parameters

Many parameters use 1750 floating point notation. Refer to the end of the table for the definition of this number notation.

Scan Control Table (SCT)

Table Ref = 2

Data Ref	Octet	Parameter Name	Definition	Default (in PROM) Value (hex)	Default (in PROM) Value (Engineering)	Verification (read memory) Address (hex)	Verification (read memory) Format
0	1	RDM SDA max demand code (RDM_DIG_C_MAX)	FF=DAC full scale	F0	240 decimal	109BA	32 bit FP
	2	FDM SDA max demand code (FDM_DIG_C_MAX)	FF=DAC full scale	F3	243 decimal	109CC	32 bit FP
	3	Cog/Ripple torque compensation enable/disable	bit 1 (MSB): 0 = cogging torque disabled 1 = cogging torque enabled bit 2 : 0 = ripple torque disabled 1 = ripple torque enabled bits 3..8(LSB) : unused	80	cogging enabled, ripple disabled	Bit 1 – 10861 Bit 2 – 108CD	16 bit Boolean 16 bit Boolean (0000 = disabled) (0001 = enabled)
	4	Delay parameter	0..7: 0 = no delay; 7=max delay.	00	Delay = 0	10864	32 bit FP
1	1	Earth Scan position error tolerance	1 LSB = 0.01° (therefore full scale = 2.55°)	0A	0.10°	108D0	32 bit FP
	2	Calibration targets position error tolerance	1 LSB = 0.01° (therefore full scale = 2.55°)	3C	0.6°	108CE	32 bit FP
	3	Fixed View position error tolerance	1 LSB = 0.01° (therefore full scale = 2.55°)	3C	0.6°	10895	32 bit FP
	4	unused	N/A	00	N/A	N/A	N/A
2	1	Position measurement initialisation velocity	1 LSB = 5°/second	0C	60°/s	108AF	32 bit FP
	2	unused	N/A	00	N/A	N/A	N/A
	3	unused	N/A	00	N/A	N/A	N/A
	4	unused	N/A	00	N/A	N/A	N/A

Data Ref	Octet	Parameter Name	Definition	Default (in PROM)		Verification (read memory)	
3	1	Profile	00 = Profile 0 01 = Profile 1 02 = Profile 2 03 = Manual Profile	00	Profile 0	13003	8 bit integer
	2	unused	N/A	00	N/A	N/A	N/A
	3	unused	N/A	00	N/A	N/A	N/A
	4	unused	N/A	00	N/A	N/A	N/A
4	1..4	RDM_MOI	RDM moment of inertia (kg.m2)	4B 87 BE FA	9.22e-3	108B7	32 bit FP
5	1..4	RDM_K_motor	motor constant (N.m/Amp)	72 4D D3 00	0.893	1089F	32 bit FP
6	1..4	RDM_SDA_k0	amplifier offset (LSBs)	00 00 00 00	0.0	109BC	32 bit FP
7	1..4	RDM_SDA_k1	amplifier gain (LSBs per Amp)	60 94 7B 08	193.16	109BE	32 bit FP
8	1..4	RDM_Ind_A	Inductosyn correction, amplitude (°)	00 00 00 00	0.0	108A3	32 bit FP
9	1..4	RDM_Ind_N	Inductosyn correction, frequency (cycles/rev)	64 00 00 06	50.0	108B3	32 bit FP
10	1..4	RDM_Ind_θ	Inductosyn correction, phase (°)	00 00 00 00	0.0	108B5	32 bit FP
11	1..4	RDM_Ind_offset_A	Inductosyn correction, zero position A offset (°)	00 00 00 00	0.0	109C0	32 bit FP
12	1..4	RDM_cog_A1	Cogging torque correction 1, amplitude (N.m)	51 EB 85 FB	0.02	10899	32 bit FP
13	1..4	RDM_cog_N1	Cogging torque correction 1, frequency (cycles/rev)	4E 00 00 08	156.0	1089B	32 bit FP
14	1..4	RDM_cog_θ1	Cogging torque correction 1, phase (°)	00 00 00 00	0.0	1089D	32 bit FP
15	1..4	RDM_ripple_A	Ripple torque correction, amplitude (N.m)	77 5F 70 00	0.9326	108BB	32 bit FP
16	1..4	unused	N/A	00 00 00 00	N/A	N/A	N/A
17	1..4	unused	N/A	00 00 00 00	N/A	N/A	N/A
18	1..4	RDM_ripple_θ	Ripple torque correction, phase (°)	00 00 00 00	0.0	108BF	32 bit FP
19	1..4	RDM_Scan_kp	Scan Mode proportional term gain (N.m/°)	5D 6A 16 FF	0.3649	108B9	32 bit FP
20	1..4	RDM_Scan_ki	Scan Mode integral term gain (N.m/(°.s))	4B 9D B2 03	4.726	108B1	32 bit FP
21	1..4	RDM_Scan_kv	Scan Mode derivative term gain (N.m/(°/s))	6B B9 8C FA	0.01315	108A1	32 bit FP
22	1..4	RDM_Scan_k	Scan Mode global gain	40 00 00 01	1.0	108A5	32 bit FP
23	1..4	RDM_FV_kp	Fixed View Mode proportional term gain (N.m/°)	77 65 FE FF	0.4664	108AD	32 bit FP
24	1..4	unused	N/A	00 00 00 00	N/A	N/A	N/A
25	1..4	RDM_FV_kv	Fixed View Mode derivative term gain (N.m/(°/s))	6B B9 8C FA	0.01315	108A7	32 bit FP
26	1..4	RDM_FV_k	Fixed View Mode global gain	40 00 00 01	1.0	108A9	32 bit FP
27	1..4	FDM_MOI	FDM moment of inertia (kg.m2)	48 D3 AE FA	8.89e-3	10885	32 bit FP
28	1..4	FDM_K_motor	motor constant (N.m/Amp)	70 E5 60 00	0.882	1086F	32 bit FP
29	1..4	FDM_SDA_k0	amplifier offset (LSBs)	00 00 00 00	0.0	109CE	32 bit FP
30	1..4	FDM_SDA_k1	amplifier gain (LSBs per Amp)	60 94 7B 08	193.16	109D0	32 bit FP
31	1..4	FDM_Ind_A	Inductosyn correction, amplitude (°)	00 00 00 00	0.0	10873	32 bit FP

Data Ref	Octet	Parameter Name	Definition	Default (in PROM)		Verification (read memory)	
32	1..4	FDM_Ind_N	Inductosyn correction, frequency (cycles/rev)	64 00 00 06	50.0	10881	32 bit FP
33	1..4	FDM_Ind_θ	Inductosyn correction, phase (°)	00 00 00 00	0.0	10883	32 bit FP
34	1..4	unused	N/A	00 00 00 00	N/A	N/A	N/A
35	1..4	FDM_cog_A	Cogging torque correction, amplitude (N.m)	00 00 00 00	0.0	10869	32 bit FP
36	1..4	FDM_cog_N	Cogging torque correction, frequency (cycles/rev)	00 00 00 00	0.0	1086B	32 bit FP
37	1..4	FDM_cog_θ	Cogging torque correction, phase (°)	00 00 00 00	0.0	1086D	32 bit FP
38	1..4	FDM_ripple_A	Ripple torque correction, amplitude (N.m)	77 5F 70 00	0.9326	10889	32 bit FP
39	1..4	unused	N/A	00 00 00 00	N/A	N/A	N/A
40	1..4	unused	N/A	00 00 00 00	N/A	N/A	N/A
41	1..4	FDM_ripple_θ	Ripple torque correction, phase (°)	00 00 00 00	0.0	1088D	32 bit FP
42	1..4	FDM_Scan_kp	Scan Mode proportional term gain (N.m/°)	63 46 DC FF	0.3878	10887	32 bit FP
43	1..4	unused	N/A	00 00 00 00	N/A	N/A	N/A
44	1..4	FDM_Scan_kv	Scan Mode derivative term gain (N.m/(°/s))	4A 0E 41 FA	0.009040	10871	32 bit FP
45	1..4	FDM_Scan_k	Scan Mode global gain	40 00 00 01	1.0	10875	32 bit FP
46	1..4	FDM_FV_kp	Fixed View Mode proportional term gain (N.m/°)	73 1F 8A FF	0.4497	1087F	32 bit FP
47	1..4	unused	N/A	00 00 00 00	N/A	N/A	N/A
48	1..4	FDM_FV_kv	Fixed View Mode derivative term gain (N.m/(°/s))	67 DF E3 FA	0.01268	10877	32 bit FP
49	1..4	FDM_FV_k	Fixed View Mode global gain	40 00 00 01	1.0	1087B	32 bit FP
50	1..4	alpha	Ratio of inertia : RDM/FDM	40 00 00 01	1.0	10897	32 bit FP
51	1..4	gamma1	Profile 0 calculation: acceleration 1 (°/s/s)	4A 79 9A 0D	4766.4000008	14F8D	32 bit FP
52	1..4	gamma2	Profile 0 calculation: acceleration 2 (°/s/s)	50 56 BA 0D	5141.6816329	14F8F	32 bit FP
53	1..4	gamma3	Profile 0 calculation: acceleration 3 (°/s/s)	4D 7E CC 0D	4959.6990058	14F91	32 bit FP
54	1..4	speed	Profile 0 calculation: scan velocity (°/s)	78 00 00 06	60.0°/s	14F93	32 bit FP
55	1,2	c1	Profile 0 calculation: phase 1 end: (COUNTs)	02 D0	720 (note 1)	14F84	16 bit integer
	3,4	c2	Profile 0 calculation: phase 2 end: (COUNTs)	02 E8	744	14F85	16 bit integer
56	1,2	c3	Profile 0 calculation: phase 3 end: (COUNTs)	03 00	768 (note 1)	14F86	16 bit integer
	3,4	c4	Profile 0 calculation: phase 4 end: (COUNTs)	03 20	800 (note 1)	14F87	16 bit integer
57	1,2	c5	Profile 0 calculation: phase 5 end: (COUNTs)	03 58	856	14F88	16 bit integer
	3,4	c6	Profile 0 calculation: phase 6 end: (COUNTs)	03 90	912 (note 1)	14F89	16 bit integer
58	1,2	c7	Profile 0 calculation: phase 7 end: (COUNTs)	03 B0	944 (note 1)	14F8A	16 bit integer
	3,4	c8	Profile 0 calculation: phase 8 end: (COUNTs)	03 ED	1005	14F8B	16 bit integer
59	1,2	c9	Profile 0 calculation: phase 9 end: (COUNTs)	04 2A	1066	14F8C	16 bit integer
	3,4	unused	N/A	00 00 00 00	N/A	N/A	N/A
60	1..4	gamma1	Profile 1 calculation: acceleration 1 (°/s/s)	52 F1 AA 0D	5308.4160032	14F9E	32 bit FP
61	1..4	gamma2	Profile 1 calculation: acceleration 2 (°/s/s)	48 AF 1B 0D	4651.7760000	14FA0	32 bit FP

Data Ref	Octet	Parameter Name	Definition	Default (in PROM)		Verification (read memory)	
62	1..4	gamma3	Profile 1 calculation: acceleration 3 (°/s/s)	4D 7E CC 0D	4959.6990058	14FA2	32 bit FP
63	1..4	speed	Profile 1 calculation: scan velocity (°/s)	78 00 00 06	60.0°/s	14FA4	32 bit FP
64	1,2	c1	Profile 1 calculation: phase 1 end: (COUNTs)	02 D0	720 (note 1)	14F95	16 bit integer
	3,4	c2	Profile 1 calculation: phase 2 end: (COUNTs)	02 E4	740	14F96	16 bit integer
65	1,2	c3	Profile 1 calculation: phase 3 end: (COUNTs)	02 F8	760 (note 1)	14F97	16 bit integer
	3,4	c4	Profile 1 calculation: phase 4 end: (COUNTs)	03 18	792 (note 1)	14F98	16 bit integer
66	1,2	c5	Profile 1 calculation: phase 5 end: (COUNTs)	03 54	852	14F99	16 bit integer
	3,4	c6	Profile 1 calculation: phase 6 end: (COUNTs)	03 90	912 (note 1)	14F9A	16 bit integer
67	1,2	c7	Profile 1 calculation: phase 7 end: (COUNTs)	03 B0	944 (note 1)	14F9B	16 bit integer
	3,4	c8	Profile 1 calculation: phase 8 end: (COUNTs)	03 ED	1005	14F9C	16 bit integer
68	1,2	c9	Profile 1 calculation: phase 9 end: (COUNTs)	04 2A	1066	14F9D	16 bit integer
	3,4	unused	N/A	00 00 00 00	N/A	N/A	N/A
69	1..4	gamma1	Profile 2 calculation: acceleration 1 (°/s/s)	43 1D 42 0D	4295.3142852	14FAF	32 bit FP
70	1..4	gamma2	Profile 2 calculation: acceleration 2 (°/s/s)	59 94 4C 0D	5733.0745568	14FB1	32 bit FP
71	1..4	gamma3	Profile 2 calculation: acceleration 3 (°/s/s)	4D 7E CC 0D	4959.6990058	14FB3	32 bit FP
72	1..4	speed	Profile 2 calculation: scan velocity (°/s)	78 00 00 06	60.0°/s	14FB5	32 bit FP
73	1,2	c1	Profile 2 calculation: phase 1 end: (COUNTs)	02 D0	720 (note 1)	14FA6	16 bit integer
	3,4	c2	Profile 2 calculation: phase 2 end: (COUNTs)	02 EC	748	14FA7	16 bit integer
74	1,2	c3	Profile 2 calculation: phase 3 end: (COUNTs)	03 08	776 (note 1)	14FA8	16 bit integer
	3,4	c4	Profile 2 calculation: phase 4 end: (COUNTs)	03 28	808 (note 1)	14FA9	16 bit integer
75	1,2	c5	Profile 2 calculation: phase 5 end: (COUNTs)	03 5C	860	14FAA	16 bit integer
	3,4	c6	Profile 2 calculation: phase 6 end: (COUNTs)	03 90	912 (note 1)	14FAB	16 bit integer
76	1,2	c7	Profile 2 calculation: phase 7 end: (COUNTs)	03 B0	944 (note 1)	14FAC	16 bit integer
	3,4	c8	Profile 2 calculation: phase 8 end: (COUNTs)	03 ED	1005	14FAD	16 bit integer
77	1,2	c9	Profile 2 calculation: phase 9 end: (COUNTs)	04 2A	1066	14FAE	16 bit integer
	3,4	unused	N/A	00 00 00 00	N/A	N/A	N/A
78	1,2	Start_integration	Scan Mode integral term start updates 0..1151 (counts)	00 00	0 (= Earth View start)	108D2	16 bit integer
	3,3	Stop_integration	Scan Mode integral term stop updates 0,,1151 (counts)	02 D0	720 (= Earth View end)	10866	16 bit integer
79	1..4	Epsilon_max	Error constant for limiting Fixed View torque (°) (=Vmax * RDM_FV_kv / RDM_FV_kp)	5A 39 58 02	2.8195	10867	32 bit FP
80	1..4	RDM_vel_kv	RDM constant velocity alg. derivative gain (N.m/(°/s))	6B B9 8C FA	0.01315	108C7	32 bit FP
81	1..4	RDM_vel_k	RDM constant velocity alg. global gain	40 00 00 01	1.0	108C9	32 bit FP
82	1..4	FDM_vel_kv	FDM constant velocity alg. derivative gain (N.m/(°/s))	67 DF E3 FA	0.01268	1088F	32 bit FP
83	1..4	FDM_vel_k	FDM constant velocity alg. global gain	40 00 00 01	1.0	10891	32 bit FP
84	1..4	RDM_Ind_offset_B	Inductosyn correction, zero position B offset (°)	5A 00 00 08	180.0	109C2	32 bit FP

Data Ref	Octet	Parameter Name	Definition	Default (in PROM)		Verification (read memory)	
85	1..4	RDM_vel_kp	RDM constant vel. alg. proportional term (N.m/°)	77 65 FE FF	0.4664	108CB	32 bit FP
86	1..4	FDM_vel_kp	FDM constant vel. alg. proportional term (N.m/°)	73 1F 8A FF	0.4497	10893	32 bit FP
87	1..4	RDM_scan_epsilon0	RDM scan algorithm initial control error (°)	00 00 00 00	0.0	108C1	32 bit FP
88	1..4	RDM_scan_i0	RDM scan algorithm initial integral term (°.s)	00 00 00 00	0.0	108C3	32 bit FP
89	1..4	RDM_scan_d0	RDM scan algorithm initial derivative term (°/s)	00 00 00 00	0.0	108C5	32 bit FP
90	1..4	RDM_cog_A2	Cogging torque correction 2, amplitude (N.m)	00 00 00 00	0.0	108D7	32 bit FP
91	1..4	RDM_cog_N2	Cogging torque correction 2, frequency (cycles/rev)	00 00 00 00	0.0	108DF	32 bit FP
92	1..4	RDM_cog_θ2	Cogging torque correction 2, phase (°)	00 00 00 00	0.0	108E7	32 bit FP
93	1..4	RDM_cog_A3	Cogging torque correction 3, amplitude (N.m)	00 00 00 00	0.0	108D9	32 bit FP
94	1..4	RDM_cog_N3	Cogging torque correction 3, frequency (cycles/rev)	00 00 00 00	0.0	108E1	32 bit FP
95	1..4	RDM_cog_θ3	Cogging torque correction 3, phase (°)	00 00 00 00	0.0	108E9	32 bit FP
96	1..4	RDM_cog_A4	Cogging torque correction 4, amplitude (N.m)	00 00 00 00	0.0	108DB	32 bit FP
97	1..4	RDM_cog_N4	Cogging torque correction 4, frequency (cycles/rev)	00 00 00 00	0.0	108E3	32 bit FP
98	1..4	RDM_cog_θ4	Cogging torque correction 4, phase (°)	00 00 00 00	0.0	108EB	32 bit FP
99	1..4	RDM_cog_A5	Cogging torque correction 5, amplitude (N.m)	00 00 00 00	0.0	108DD	32 bit FP
100	1..4	RDM_cog_N5	Cogging torque correction 5, frequency (cycles/rev)	00 00 00 00	0.0	108E5	32 bit FP
101	1..4	RDM_cog_θ5	Cogging torque correction 5, phase (°)	00 00 00 00	0.0	108ED	32 bit FP

Note 1 : these values must be divisible by 8 so that the pixel acquisition system is synchronised to the Scan Control.

Where 4 bytes (ie. 1..4) are assigned to a parameter, these use the 1750 standard precision floating point representation (32 bit), with the following format:-

SCT Table reference	Octet 1	Octet 2	Octet 3	Octet 4
Memory Read	Address (MS)	Address (LS)	Address +1 (MS)	Address + 1 (LS)
Floating Point notation	24 bit mantissa			8 bit exponent

Mantissa = fractional two's complement - normalised
Exponent = two's complement.

Appendix D: DC Offsets Table (DOT)

The DOT defines parameters which are used by the Science Data acquisition system, related to maintaining the Rx input signals within the ADC dynamic range.

Table Ref: 3

Data Ref	Octet	Parameter Name	Definition	Default (in PROM)		Verification (read memory)	
				Value (hex)	Value (Engineering)	Memory Address (hex)	Format
0	1	Channel H1 DC Offset	FF = 10V	5A	3.5V	10810 (LS)	8 bit integer
	2	Channel H2 DC Offset	FF = 10V	D1	8.2V	10811 (LS)	8 bit integer
	3	Channel H3 DC Offset	FF = 10V	AB	6.7V	10812 (LS)	8 bit integer
	4	Channel H4 DC Offset	FF = 10V	BA	7.3V	10813 (LS)	8 bit integer
1	1	Channel H5 DC Offset	FF = 10V	AE	6.8V	10814 (LS)	8 bit integer
	2	SPE Channel Gain	1 LSB = 0.05	85	Gain = 6.65	107E6	32 bit FP
	3,4	Ideal calibration mid-point	FFF0 = fullscale	732C	45% of Full Scale	107E5	16 bit integer
2	1,2	Upper Deadband	FFF0 = fullscale	F324	95% of Full Scale	107E1	16 bit integer
	3,4	Lower Deadband	FFF0 = fullscale	0CCC	5% of Full Scale	107E2	16 bit integer
3	1,2	Max Dynamic Range	FFF0 = fullscale	E658	90% of Full Scale	107E3	16 bit integer
	3,4	Min Dynamic Range	FFF0 = fullscale	BFF4	75% of Full Scale	107E4	16 bit integer

Appendix E: Initialization of Software Parameters

Table Parameter Name	Table & Data Ref	Default (in PROM)	EM	PFM	FM2	FM3	FM4	*FM5*
H1 LO Redundancy H2 LO Redundancy H3/4 LO Redundancy H5 LO Redundancy H1 Rx Gain H2 Rx Gain H3 Rx Gain	ICT1	Side A Side A Side A Side A 0dB 0dB 0dB AA,AA,AA,49	PROM PROM Side B PROM PROM PROM PROM AA,9A,AA,49	PROM PROM PROM PROM PROM PROM PROM n/a	Side B Side B Side B PROM PROM PROM PROM 99,9A,AA,49	PROM PROM Side B PROM PROM PROM PROM AA,9A,AA,49	PROM Side B PROM Side B PROM PROM PROM A9,AA,9A,49	***TBD***
H4 Rx Gain H5 Rx Gain	ICT2	0dB 0dB 20,00,00,00	PROM PROM n/a	2dB PROM 60,00,00,00	PROM PROM n/a	PROM PROM n/a	PROM PROM n/a	***TBD***
H1 DC Offset H2 DC Offset H3 DC Offset H4 DC Offset	DOT0	3.5V 8.2V 6.7V 7.3V 5A,D1,AB,BA	3.6V 4.8V 3.2V 2.1V 5D,7B,52,37	2.5V 3.7V 2.7V 1.5V 3F,5E,46,27	2.5V 3.3V 3.4V 3.0V 3F,55,56,4C	2.5V 3.3V 3.4V 3.0V 3F,55,56,4C	2.5V 3.3V 3.4V 3.0V 3F,55,56,4C	***TBD***
H5 DC Offset SPE Gain	DOT1	6.8V 6.65 AE,85,73,2C	0.7V PROM 13,85,73,2C	3.4V 6.50 57,82,73,2C	2.2V 6.50 38,82,73,2C	2.2V 6.50 38,82,73,2C	2.2V 6.50 38,82,73,2C	***TBD***
SPE Min Dynamic Range	DOT3	75% E6,58,BF,F4	50% E6,58,7F,F8	50% E6,58,7F,F8	50% E6,58,7F,F8	50% E6,58,7F,F8	50% E6,58,7F,F8	***TBD***
RF Bore offset - Inductosyn Bias Error =Inductosyn Zero Pos'n Offset (A)	SCT11	0.00 -0.00 =0.00 00,00,00,00	64.9589 -0.0489 =64.91 40,E8,F6,07	62.71 -0.00 =62.71 7D,6B,85,06	154.473 -0.04 = 154.433 4D,37,6D,08	153.656 -0.00 =153.656 4C,D3,F8,08	333.592 -0.00 =333.592 53,65,E3,09	***TBD***
Inductosyn Zero Pos'n Offset (B) (=Sensor A offset +180)	SCT84	180.0 5A,00,00,08	244.91 7A,74,7B,08	242.71 79,5A,E1,08	334.433 53,9B,B6,09	333.656 53,69,FC,09	153.592 4C,CB,C7,08	***TBD***

Table Parameter Name	Table & Data Ref	Default (in PROM)	EM	PFM	FM2	FM3	FM4	*FM5*
Earth Scan position error tolerance	SCT1	0.1° 0A,3C,3C,00	0.15° 0F,3C,3C,00	0.15° 0F,3C,3C,00	0.15° 0F,3C,3C,00	0.15° 0F,3C,3C,00	0.15° 0F,3C,3C,00	***TBD***
Cogging correction 1: amplitude	SCT12	0.02 51,EB,86,FB	0.015 7A,E1,48,FA	PROM n/a	0.008 41,89,38,FA	PROM n/a	0.012 62,4D,D2,FA	***TBD***
Cogging correction 1: frequency	SCT13	156 4E,00,00,08	39 4E,00,00,06	PROM n/a	24 60,00,00,05	PROM n/a	11.5 5C,00,00,04	***TBD***
Cogging correction 1: phase	SCT14	0 00,00,00,00	180 5A,00,00,08	PROM n/a	320 50,00,00,09	PROM n/a	210 69,00,00,08	***TBD***
Cogging correction 2: amplitude	SCT90	0 00,00,00,00	0.002 41,89,38,F8	PROM n/a	0.011 5A,1C,AC,FA	PROM n/a	0.004 41,89,38,F9	***TBD***
Cogging correction 2: frequency	SCT91	0 00,00,00,00	13 68,00,00,04	PROM n/a	12 60,00,00,04	PROM n/a	23 5C,00,00,05	***TBD***
Cogging correction 2: phase	SCT92	0 00,00,00,00	PROM n/a	PROM n/a	240 78,00,00,08	PROM n/a	290 48,80,00,09	***TBD***
RDM SDA Max demand code FDM SDA Max demand code Cogging corrections	SCT0	F0 F3 Enabled F0,F3,80,00	PROM PROM PROM n/a	F4 F6 Disabled F4,F6,00,00	EE F6 Enabled EE,F6,80,00	EE F6 Enabled EE,F6,80,00	F5 EF Enabled F5,EF,80,00	***TBD***
RDM SDA amplifier gain	SCT7	193.16 60,94,7B,08	PROM n/a	196.0 62,00,00,08	190.0 5F,00,00,08	190.0 5F,00,00,08	196 62,00,00,08	***TBD***
FDM SDA amplifier gain	SCT30	193.16 60,94,7B,08	PROM n/a	196.0 62,00,00,08	196.0 62,00,00,08	196.0 62,00,00,08	191.0 5F,80,00,08	***TBD***
RDM Standby Mode Current Limits Upper Fault Upper Warning Lower Warning Lower Fault	TLT 87	303mA 193A 0mA 0mA 16,0E,00,00	620mA 565mA PROM PROM 2D,29,00,00	620mA 565mA PROM PROM 2D,29,00,00	620mA 565mA PROM PROM 2D,29,00,00	620mA 565mA PROM PROM 2D,29,00,00	620mA 565mA PROM PROM 2D,29,00,00	***TBD***

Table Parameter Name	Table & Data Ref	Default (in PROM)	EM	PFM	FM2	FM3	FM4	*FM5*
FDM Standby Mode Current Limits								***TBD***
Upper Fault		303mA	620mA	620mA	620mA	620mA	620mA	
Upper Warning		193A	565mA	565mA	565mA	565mA	565mA	
Lower Warning		0mA	PROM	PROM	PROM	PROM	PROM	
Lower Fault		0mA	PROM	PROM	PROM	PROM	PROM	
	TLT 90	16,0E,00,00	2D,29,00,00	2D,29,00,00	2D,29,00,00	2D,29,00,00	2D,29,00,00	
RDM Scan Mode Current Limits								***TBD***
Upper Fault		881mA	1281mA	1281mA	1281mA	1281mA	1281mA	
Upper Warning		826mA	PROM	PROM	PROM	PROM	PROM	
Lower Warning		0mA	PROM	PROM	PROM	PROM	PROM	
Lower Fault		0mA	PROM	PROM	PROM	PROM	PROM	
	TLT 88	40,3C,00,00	5D,3C,00,00	5D,3C,00,00	5D,3C,00,00	5D,3C,00,00	5D,3C,00,00	
FDM Scan Mode Current Limits								***TBD***
Upper Fault		881mA	1281mA	1281mA	1281mA	1281mA	1281mA	
Upper Warning		826mA	PROM	PROM	PROM	PROM	PROM	
Lower Warning		0mA	PROM	PROM	PROM	PROM	PROM	
Lower Fault		0mA	PROM	PROM	PROM	PROM	PROM	
	TLT 91	40,3C,00,00	5D,3C,00,00	5D,3C,00,00	5D,3C,00,00	5D,3C,00,00	5D,3C,00,00	
5V Power-on Mode Current Limits								***TBD***
Upper Fault		773mA	1194mA	1194mA	1194mA	1194mA	1194mA	
Upper Warning		706mA	1093mA	1093mA	1093mA	1093mA	1093mA	
Lower Warning		572mA	504mA	504mA	504mA	504mA	504mA	
Lower Fault		504mA	387mA	387mA	387mA	387mA	387mA	
	TLT 92	2E,2A,22,1E	47,41,1E,17	47,41,1E,17	47,41,1E,17	47,41,1E,17	47,41,1E,17	

APPENDIX F: CCSDS PACKETS

1.1 Packet Formats

All requirements of this section are applicable to all message types on the MHS Command and Telemetry Bus and Science Data Bus. The overall structure of a CCSDS message is as shown in figure 1.1-1.

Primary Header Field	Source Data Field	Packet Error Control
3 words 6 octets	variable	1 word 2 octets

Figure 1.1-1 CCSDS Packet Format

The application message level protocol is contained in the Source Data Field. This is specific to the application and the bus involved, and will be expanded upon in sections 4.2 and 4.3 of this document. Although this field is variable in length, the overall packet length is entered into one of the fields of the fixed length Primary Header Field (see the following section).

- The Primary Header Field is described in section 1.1.1.
- The Source Data Field is described in section 1.1.2.
- The Packet Error Control Field is described in section 1.1.3.

1.1.1 Primary Header Field

All Primary Header Fields for the entire MHS message set will conform to the general format as shown in Figure 1.1.1-1.

Subfield Name	Size (Octets)
Packet ID Field	2
Packet Sequence Control	2
Packet Length Field	2

Figure 1.1.1-1 Primary Header Format

1.1.1.1 Packet ID Field

The Packet ID Field will follow the format shown in figure 1.1.1.1-1.

The Version, the Secondary Header Flag and the Application Process ID will be constant for all MHS packet types. The type will obviously change between received telecommands and generated telemetry.

Bit Position	Subfield Name	Set to	Code
0..2	Version	'Version 1'	000
3	Type	'TM' or 'TC'	0 = TM packets 1 = TC packets
4	Secondary Header Flag	'Header present'	1
5..15	Application process ID	'MHS'	022 hex for all models

Figure 1.1.1.1-1 Packet ID Field Format

1.1.1.2 Packet Sequence Control Field

The Packet Sequence Control Field will follow the format shown in figure 1.1.1-2.

Bit Position	Subfield name	Set to	Code
0..1	Segment Flags	'Stand-alone'	11
2..15	Source Sequence Count	incremented for each packet	modulo-n count

Figure 1.1.1.2-1 Packet Sequence Control Format

The segment flags are used to show the relation of the current packet to other packets. Segmented Telemetry packets are forbidden in the system. Telecommand segmentation is permitted, but none of the proposed telecommand types will fit into this category. This code will therefore remain constant for all MHS packets.

Source Sequence Count is a method of counting the number of packets generated on the bus by the application. The significant parameter is a sequential count of the Packet Sequence Control Fields. This field will start with a value of 16#0000# and increment to 16#3FFF#. At this point it will roll-over and continue again from 16#0000#. The counts for the Command and Telemetry Bus and for the Science Data Bus will be independent. The count will re-start from 0 after power-on. Note that the count is a count of packets transferred on the bus, and not packets generated. For example, the same telemetry packet may be collected twice by the MIU and the time code and data content of the two packets will be identical, but the sequence count will not.

At power-on initialisation, an 'initialisation packet' is generated on the Command/Telemetry Bus. This packet will always have a zero packet sequence count, irrespective of the number of times it is transferred, until the MINOS is fully initialised. Two source sequence counts will be maintained on each bus: one for command packets, the second for telemetry packets.

A 'missing' count on an command packet does not necessarily constitute an error condition, as the command could be declared invalid by the hardware, and might never appear at the software level. The error handling procedures of the platform are not to constrain the MINOS.

1.1.1.3 Packet Length Field

The Packet Length Field will contain a 16-bit data word which represents the remaining length in octets of the packet. The data word will contain the size of the combination of the source data field and the packet error control field, minus 1.

All MHS command packets on both the Command/Telemetry and Science Data Buses are the same length.

4.1.2 Source Data Field

The Source Data field is the region that contains the application message. There is a further CCSDS field, the Secondary Header, which is used to contain a time code. The time code shall indicate the time corresponding to the start of Earth Scan of the scan revolution for which the data applies. The optional CCSDS preamble field, which includes the epoch (i.e. the event at which t=0), is not included. The implied epoch is midnight, January 1, 1958. This time will be extracted from the on-board clock maintained by the MINOS. It will be the responsibility of the ground control to upload an absolute time. In general this will be a time value that will become valid at the next occurrence of the 8SP clock.

Source Data Field	
Subfield Name	Size (octets)
Secondary Header	6
Source Data	Variable

Figure 1.1.2-1 Source Data Field Format

Secondary Header		
Subfield Name	Size (octets)	Description
Coarse Time Code	4	1 LSB = 1 second
Fine Time Code	2	1 LSB = 2^{-16} seconds

Figure 1.1.2-2 Secondary Header Field Format

The coarse time code will contain a count of the number of seconds elapsed since the epoch, and the fine time shall contain the fractions of seconds since the last increment of the coarse field.

The Source Data itself is defined by the application, and by the bus.

4.1.3 Packet Error Control Field

Consists of a vertical parity checksum calculated by performing an exclusive-OR on all other octet pairs that constitute the packet.

REFERENCE DOCUMENTS

Astrium:

3175-JA001-SPO	MICROWAVE HUMIDITY SOUNDER DESIGN DESIG AND PERFORMANCE SPECIFICATION (MHS-GS-JA001-MMP) Issue 1, September 1997
3175-JA063-TNO	MICROWAVE HUMIDITY SOUNDER (MHS) TM-TC AND SCIENCE DATA FORMAT DIRECTORY (MHS-TN-JA063-MMP) Issue 5, January 2000
3175-JA215-MAH	MICROWAVE HUMIDITY SOUNDER (MHS) FLIGHT OPERATIONS MANUAL (MH-OM-JA215-MMP) Issue 5, September 16,2002

Lockheed Martin Corporation

IS 20046415	UNIQUE INSTRUMENT INTERFACE SPECIFICATION FOR THE MICROWAVE HUMIDITY SOUNDER (MHS) Revision J, February 5, 2002
PS 20057860	PERFOMANCE SPECIFICATION MHS INTERFACE UNIT Revision A, June5, 1997
8590724	MICROWAVE HUMIDITY SOUNDER (MHS)/MHS INTER-FACE UNIT (MIU) USERS GUIDE Revision 0, March 10,2003